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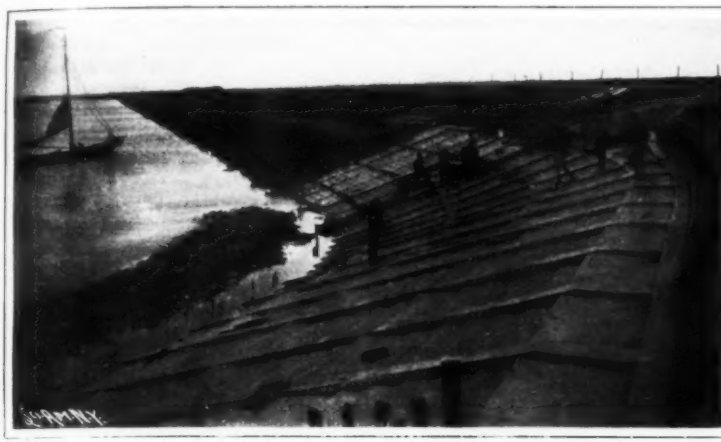
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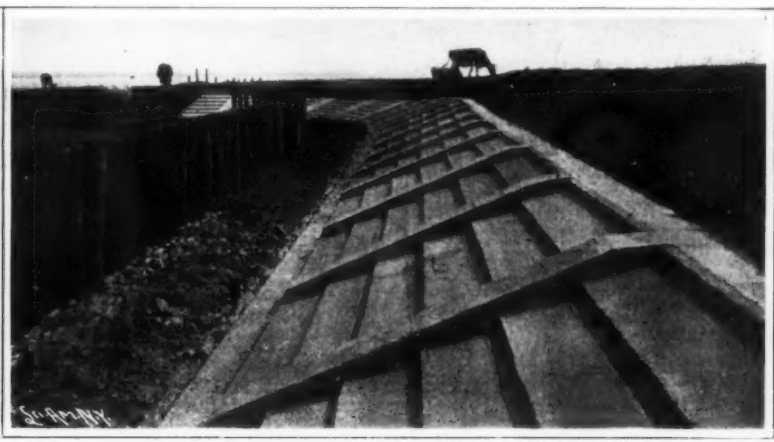
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A STRETCH OF REINFORCED CONCRETE SEA DEFENSES.



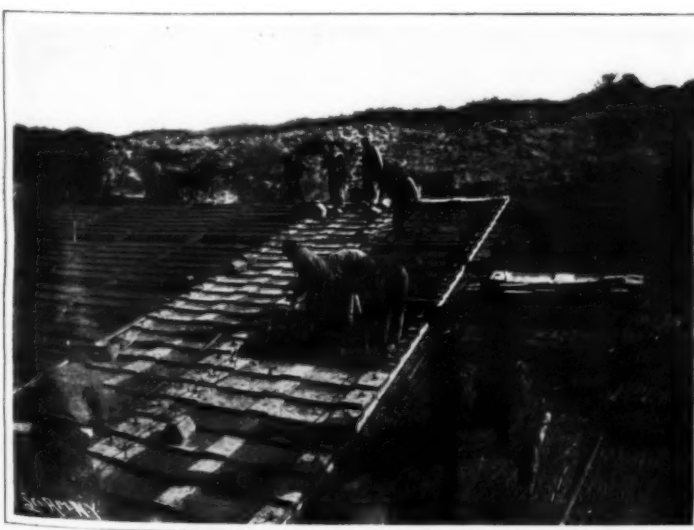
A FINISHED SUPERIOR SLOPE; TRANSVERSE RIDGES INCLOSE REINFORCEMENT.



PROTECTION OF DOWNS, SHOWING PREPARATORY LEVELING AND SMOOTHING OF BANK.



BUILDING SEA GROYNF, SHOWING TIMBER FRAME AND EXPANDED METAL. THE FRAME IS PLACED IN POSITION AND THE CEMENT DUMPED IN.



PROTECTION OF DOWNS, SHOWING THE PLACING OF STRAW MATTING, LAYING SLIPS, AND THE FINISHED SLABS.



BUILDING A GROYNF, THIS IS AN ENTIRELY NEW DEVELOPMENT IN THE APPLICATION OF REINFORCED CONCRETE.

THE REINFORCED CONCRETE SYSTEM OF SEA DEFENSES.

THE DE MURALT SYSTEM OF REINFORCED CONCRETE SEA DEFENSES.

A NEW USE FOR CONCRETE.

BY THE ENGLISH CORRESPONDENT OF THE SCIENTIFIC AMERICAN.

In low-lying countries bordering on the sea, where the latter is continually threatening inundation or erosion of the coast, more particularly at high water and during storms, the question of protecting the

ralt system is especially applicable to five salient characteristic descriptions of coast defense work, each of which is carried out upon individual lines to achieve the desired end. These may be classified as follows:



A SEA GROYPE EXECUTED IN REINFORCED CONCRETE.

exposed land becomes a problem of supreme importance. Especially is this the case with countries like Holland, where the struggle between the sea and land is interminable. During exceptionally high tides these embankments suffer considerable damage, and the safety of vast areas of country behind them becomes seriously imperiled. The ravages of the sea on the coast of Holland that were caused by the exceptionally high tides which prevailed last March were unusually destructive, more particularly in the province of Zeeland, and to resist the further inroads of the sea several miles of new dikes had to be constructed. In view of the unique position of Holland, and the practical absence of any native stone, the question of erecting substantial embankments capable of withstanding the forces set up by the waves becomes a matter beset with many difficulties. The masonry required for the purpose has to be imported, so that the defensive work can only be carried out at great expense. In order to reduce the costly nature of this work, highly successful experiments have been carried out with ferro-concrete, and this type of construction is being widely adopted as affording not only a cheaper and quicker means of combating the sea, but one of a more durable nature. The system adopted is that which has been evolved by Mr. de Muralt of the corps of State Engineers, of Zieriksee, in the province of Zeeland, who has patented the distinctive features of his process, and to whose courtesy we are indebted for the information concerning his method and the illustrations accompanying this article.

The de Muralt system is applicable to all phases of land protective work, such as the erection of new embankments, the protection of sloping beaches, and the further elevation of existing seawalls. Owing to the simplicity of the method, it enables the work not only to be carried out more expeditiously and economically than the ordinary masonry structures, but at the same time it possesses a greater factor of strength, and can resist to a more efficient degree the peculiar action of the waves, which often succeeds in loosening some of the masonry blocks, thereby enabling severe erosive action to occur. The de Mu-

1. The defense of the stronger parts of a sea slope or beach.
2. The defense of the inferior and defective stretches of beach.
3. The defense of downs.
4. The protection of shores and embankments by piers and groynes thrown out vertically from the shore



CONSTRUCTING A CONCRETE PROTECTING SLOPE.

into the sea for the purpose of breaking the wave action, or diverting strong currents.

5. The raising of existing seawalls.

In all these cases the fundamental principle of carrying out the operation in concrete armored with expanded metal or some other suitable material is adopted, but the process in each instance according to the prevailing requirements is differently applied.

THE DEFENSE OF BEACHES.

For the construction of the sloping faces of the seawalls in this material, the slope is first leveled so as to provide a flat, even working surface. Small wooden piles are then driven into the soil and placed about 12 inches apart, from center to center, the heads of the piles projecting above the working level for $\frac{1}{2}$ inch or 1 inch. A sheet of expanded metal forming the armoring of the concrete is then laid over the projecting heads of these piles. When the piles have been driven in, wooden beams notched so as to form steps are laid upon either side of the section, and are kept in position by means of iron bars. Transverse beams are then laid across the notches so as to form steps and act as molds for the concrete. As the task of fixing the transverse wooden members proceeds, the filling up of the molds with concrete is carried out, commencement being made from the bottom as before. The concrete is poured into the compartment and then tightly rammed down.

The concrete used for those sections of the seawall washed continuously by the flood tide is composed of Portland cement 3 parts, sand 5 parts, gravel $\frac{1}{2}$ inch to 1 inch, and trass cement $\frac{1}{2}$ part.

The construction of the ferro-concrete frame is now carried out. The notched side beams are removed from their original position and turned upside down upon the finished concrete, the notches fitting into the slabs and a level surface presented uppermost. These are laid on either edge of the finished flight of slabs, forming a conduit between the two. A channel is then dug between the two slabs to a depth of about 50 centimeters beneath the slabs. The armor metal frame is then laid in position in the channel thus formed, and the remaining space is afterward filled with concrete rammed tightly down as before up to

the level of the upper surface of the side wooden beams. The horizontal members of the concrete armoring are also sunk in position to a depth of 50 centimeters beneath the slab at the desired intervals, and are so placed that their uppermost surface comes flush with the edge of the last step of the higher adjacent slab, this step being thus considerably enlarged and raised. It should be borne in mind that



INFERIOR SLOPE, RISING FROM LOW WATER TO SEA WALL.



A GROYPE PARTLY COMPLETED.

THE REINFORCED CONCRETE SYSTEM OF SEA DEFENSES.

the whole system of the de Muralt facings is based upon the principle of "divide and rule." There is a perfect continuity between the slabs, that are only kept together and insulated from one another by a monolithic frame. It is essential that the iron armoring should run from one into the other, so as to present a perfectly homogeneous structure, and this framing cannot be satisfactorily accomplished until the slabs have sufficiently hardened.

In some instances where the slope is composed of stable earth the wooden piles can be dispensed with. In such cases after leveling off, a thin layer of concrete about an inch in thickness is applied to the earth surface instead, and upon this foundation the expanded metal and slabs are constructed in the same manner. Where the soil is especially friable, such as sand, after leveling it is covered with coarse straw to prevent its becoming broken up by the feet and movements of the laborers.

The experience gained with seawalls faced upon this system as compared with the general methods of basalt pitching or masonry has conclusively demonstrated that it possesses many distinct advantages. The stretches that have been thus protected have been carried out at a far lower expenditure than those executed in basalt or Belgian rock, despite the fact that the materials required, notably the expanded metal and the concrete, are relatively costly in Holland, since they have to be imported. Whereas the ferro-concrete ranges from \$1.20 to \$1.40 per square meter inclusive of materials and labor, the cost of carrying out similar protective work in basalt or masonry ranges from \$2 to \$3.20 per square meter. Because of its flexibility the system also lends itself to any description of sea facing. Owing to the concrete and expanded metal conforming to the configuration of the ground, and because of its homogeneous nature, subsidiary and preliminary operations, such as the sinking of foundations into the clay or down to rock, are rendered superfluous, while the utilization of mat covering is also dispensed with. It has a greater degree of efficiency and resistance to the action of storms than the general types of masonry structures. It cannot be weakened in any way, since the waves cannot force their way to the earth beneath the ferro-concrete, thereby undermining the structure. Experience with the dikes and seawalls in Holland has shown only too clearly the defenseless nature of this type of protection if the fabric is penetrated or weakened by the dislodgment of a few stones or the piercing of the structure. Once the waves succeed in forcing their way through the masonry its disruption and demolition rapidly ensue, since each succeeding wave rends the gap wider, scours the earth away from behind and beneath, with the result that great expense is entailed in repairing the break and in some instances the weakened section has to be entirely demolished and reconstructed. A realistic idea of the comparative strength and efficiency of the masonry and de Muralt facing systems was recently obtained at Schouwen in Holland, where the two methods of sea protection are adopted side by side. The heavy storms and floods to which this island is subject have repeatedly wrecked the basalt structures, but on no single occasion has the ferro-concrete been penetrated, weakened or shown signs of succumbing to the enormous action of the water. Owing to the elaborate nature of the armoring, it has been found that even should one compartment be penetrated, because of the surrounding armoring the damage is completely localized, while the damage can be immediately and cheaply repaired. Erosion of the ferro-concrete fabric is moreover out of the question, since the smooth surface offers a more resistant and durable obstacle to the wearing action of the waves. With the masonry structures the constant surging of the waves is continually eating away the rock, and the cost of maintaining these walls constitutes a heavy and continuous item. That the wear and tear of ferro-concrete is very slight is borne out by the fact that in those sections subject to tidal action, at low water shellfish, seaweeds, and other marine growths are found tenaciously clinging to the fabric and in turn assisting in preserving the structure. With masonry defenses, in the event of the ground at the foundation being scoured away, the whole wall over the undermined area collapses; but it has been found on the other hand with the ferro-concrete facing, even should the sea gain an admittance to the supporting earth or beach at the foot of the slab, further erosion is resisted by the horizontal and transverse armoring, while the heads of the piles in contact with the expanded metal, and themselves surrounded by concrete, prevent any slipping of the whole structure, and the base of the slab can be repaired without any apprehensions as to the strength of the upper parts being impaired.

One very great advantage possessed by this system is that skilled labor is not required to carry out constructional work, nor is the necessary plant of either a cumbersome or expensive nature. The prin-

ciple of breaking up the surface of the slab into steps is that a greater resistance is offered to wave action as compared with the smooth surface provided in masonry structures, the sharp edges of the slabs successfully breaking up the force of the rising swell.

THE DEFENSE OF DOWNS.

Owing to the widespread damage that has been created by the sea at the foot of the downs of the shores and beaches of Holland, and the hopeless impossibility of protecting them by any known methods, it was resolved to test the efficacy of the ferro-concrete system upon one of the worst stretches. Basalt pitching had here been abandoned on account of its prohibitive cost, since the whole material had to be quarried at a distance and transported to the site of construction, the cost of erection varying between \$3.20 and \$4.80 per square meter.

In utilizing the de Muralt principle in such instances the sand stretch is first sloped off and leveled. Before the construction is commenced the prepared ground is covered with matting for protecting and maintaining the level and smooth surface of the sand from the feet of the artisans while construction is in progress. The sand is then moistened and the wooden piles driven in the usual manner through the matting. The work of laying and ramming the concrete slabs is then continued as before. This phase of the operations is comprehensively shown in one of the illustrations. To the right is the straw matting protection, while in the center are to be seen slabs being laid, the notched side beams for forming the steps, and the principle of construction. To the extreme left may be seen slabs practically finished and awaiting the laying in position of the metal armoring. In another picture, the channels excavated for this armoring are definitely illustrated both transversely and longitudinally, the armoring running across every seventh step.

For the protection of such vulnerable points of coast as these sand downs the de Muralt system has proved especially efficient, and has withstood storms and severe wind and wave action which has proved so disastrous to other methods of protection.

Ferro-concrete upon the lines described in this article and evolved by this engineer has proved a very reliable means of defending the stretches of downs from sea erosion, while the cost is almost fifty per cent lower, since the cost of facing the shore in this manner only averages \$1.60 per square meter.

THE RAISING OF SEA WALLS.

That the system is eminently adapted to such works is shown by the illustration, which is carried out in ferro-concrete. Here again Mr. de Muralt's system of "divide and rule" is conscientiously carried through, the wall comprising nothing else but a raised top frame of the facing. It comprises blocks which after they have become set and hardened are equipped with armored adjacent slabs.

It follows as a matter of course that in increasing the height of a wall such as this in ferro-concrete, it is only possible at places where stagnant water is not expected to prevail above the summit of the seawall, since the latter only serves to check the surge or swell, i. e., water that alternately rises and falls under the action of the tides. This type of wall, owing to the principle involved in its construction, is so strong and solid that it scarcely requires armoring.

THE DEFENSE OF BEACHES BY PROJECTING PIERS AND GROYNES.

The system has also been recently applied to another phase of coast protection, i. e., the construction of piers and groynes stretching at right angles from the beach into the sea. This is an entirely new development in the application of ferro-concrete construction, and it has been attended with unique successes.

The first application of the system to such a phase of coast defense as this was carried out in raising an existing pier on the northern shore of the island of Schouwen in the province of Zeeland, which even during calm weather is exposed to the scouring action of a strong current.

The method adopted was to remove an existing layer of 45-centimeter prisms at intervals, and in their place were erected slabs of ferro-concrete upon the unprotected portions, a wooden frame being temporarily used to enable the erecting work to be accomplished. Each slab of concrete is provided with a raised back in such a way that the back of one slab is always higher than that immediately preceding it, the height diminishing seaward.

Each slab is carried a considerable distance with its rebated sides and its teeth in ferro-concrete beneath the bases of the neighboring basalt pitching, in this way preventing any losses of earth beneath the protective work or the possibility of its being disintegrated and broken up by the action of the waves. In the center each slab is provided with two strong ferro-concrete teeth.

The wooden frame is placed in position during the short interval available at low water, and the concrete

is prepared in the mortar mills simultaneously with the carrying out of this phase of the operations, being finally discharged into the compartment about a quarter of an hour before the water reaches the working level.

GREEK TEMPLES.

The cell of a Greek temple is a simple, oblong building. In the earlier periods it was probably nearly destitute of ornament, and except for the cornice, and for the smallness of the dimensions, much like a barn. Afterward a porch was added, supported by columns, and the entablature began to receive some embellishment. Even this disposition, when the front came into view, was beautiful, and more so when an additional range of columns was added to the portico. Afterward columns were added at the back also, by which means the variety and contrast produced by them would catch the attention from every point of view. The next step was to continue the columns all round. The simple cell had no particular appellation, and yet from the great multitude of temples existing in ancient Greece, many of which seem to have been very small, it is probable they were not uncommon. Temples of the second sort were said to be in antis, because in them the flank walls were prolonged beyond the front so as to form the sides of the porch, and these prolongations were terminated in pilasters having three faces, which pilasters were called antæ. The third arrangement was called prostyle, the fourth amphiprostyle, the fifth peripteral. Besides these were also the dipteral temples, having two rows of columns round the cell, and pseudodipteral, which differed from the dipteral by the want of the inner range of columns, and from the peripteral by having a much larger space between the cell and the surrounding colonnade. In all these the same general form was preserved, a simple oblong, and the admiration bestowed upon them was owing to the simplicity of form and richness of detail. This richness of detail has its limits, and the work may be overloaded, even when the ornaments do not (as they frequently do in Italian architecture) interrupt or obscure the simplicity of the design, but the liberty allowed is very wide. The simple cell must always have been deficient in that respect, for though the walls and cornices might be richly ornamented, yet these details could not have produced sufficient effect on the whole composition; for that purpose it is necessary that the building should be divided into principal masses, whose position with respect to each other must produce some degree of variety and intricacy. The temple in antis must also in some degree be deficient in richness, and no temple of this sort has been much admired; but the prostyle, and still more the amphiprostyle, if well proportioned, will always be admitted into the rank of beautiful buildings. From almost every point of view we see at least one column gracefully detaching itself from the mass of the building, and the nakedness of the side walls contrasts with the bright lights and shadows of the ends, and claims our admiration even when compared with the higher finish of the peripteral temple. The eye, however, will not be satisfied with some intricacy in the disposition of the general masses; it will require a similar gratification when it comes to examine the details; and we find this accomplished by fluting the columns, molding the capitals, dividing the frieze at least by triglyphs and frequently placing sculpture in the intervals between them; adorning the pediments with sculpture, and placing antefixæ, or ornamental convex tiles along the eaves. The ancients used two sorts of tiles in covering each building: the first were flat, but turned up at the edges; they were trays with the ends cut off, made a little smaller at one end than at the other that they might lap one into the other, but if such tiles were simply laid side by side the water would run in between them, and to prevent this other semicircular or semipolygonal, i. e., convex tiles were placed over the joint. These tiles ran in ribs, from the ridge of the roof down to the eaves, and the last of them at the eaves had an elevated and ornamented end, and the range of these ornamented ends, which in the edifices of Athens were of white marble running over the cornice, greatly enhanced the appearance of splendor, and must have had considerable influence even on the distant appearance of the building. In temples of the Ionic and Corinthian orders the richness of decoration was carried still further, though there was by no means the difference between those and a highly finished Doric temple which might at first be imagined. However, between a Doric prostyle temple and a dipteral temple of the Corinthian order the distance is immense, yet each has peculiar beauties, and he who prefers the one has no right to reproach with want of taste him who approves the other—Architect and Contract Reporter.

A system of submarine signal apparatus is now being installed on the transport "Kilpatrick" sailing between Newport News and Havana.

MOTOR STARTING DEVICES FOR GASOLINE AUTOMOBILES.

SOME INGENUOUS MECHANICAL CONTRIVANCES THAT DO AWAY WITH THE STARTING CRANK.

BY HAROLD H. BROWN.

THE use of devices by means of which a gasoline automobile motor can be started from the seat of the car is by no means confined to machines of recent

ing and change-speed control were combined in one lever, and when the driver desired to use this for starting, a grip handle was grasped. A general view

cars. This is shown in Fig. 2. A cable, *C*, passes from a grooved wheel, *P*, on the front end of the crankshaft over pulleys, *D* and *B*, to an arm connected with lever, *L*. Spring, *R*, returns the starting wheel and starting lever to normal position. When pedal *K* is depressed, it causes the starting wheel to



FIG. 1.—THE HERTEL GASOLINE RUNABOUT.

In this little gasoline car of ten years ago it was possible to start the motor from the seat and control the speed of the car as well with the one lever shown projecting upward between the two men.

date. In the winter of 1898-9 a machine known as the Hertel and having this feature was exhibited at the Madison Square Garden Cycle Show. The start-

of this device is shown in Fig. 1. Other examples of manually-operated devices that could be worked from the seat were found in the Crest, Oldsmobile, Stevens-Duryea, and the De Dion motorette.

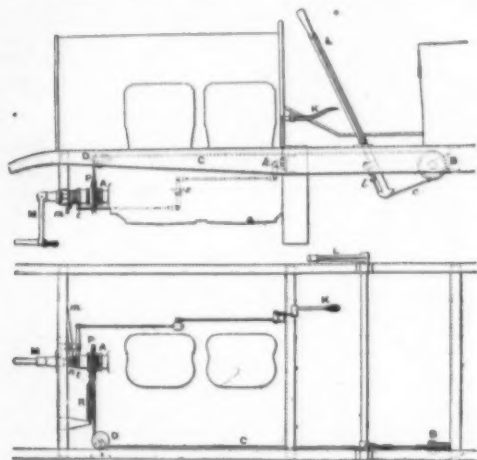


FIG. 2.—RICHARD-BRASIER SEAT STARTING DEVICE.

Cable *C* passes from wheel *P* on starting crank axle over pulleys *D* and *B* to end of lever *L*. The spring *R* returns starting crank and lever to normal position. The pedal *K*, when pushed down, puts starting crank into engagement with motor shaft by a series of levers and rods *k*, *s* and *t*. By means of the lever *m* the starting crank may be put into engagement with the motor shaft when it is desired to start the car from that position.

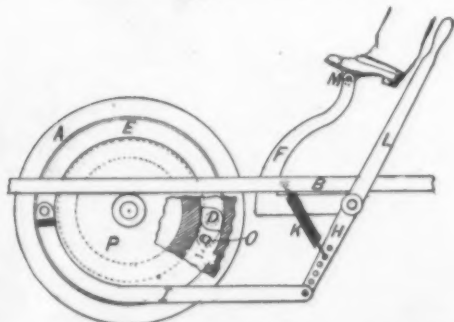


FIG. 3.—SIDE VIEW OF WILKINSON STARTER AS USED ON THE HOLMES CAR.

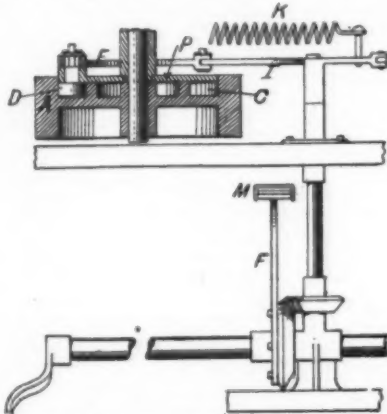


FIG. 4.—PLAN VIEW OF WILKINSON STARTER AS APPLIED TO A 4-CYLINDER CAR.

Flywheel and starter shown in cross-section.

Self-starting mechanisms have lately come into prominence owing to the adaptation of such a device on some of the 1906 models of the Richard-Brasier

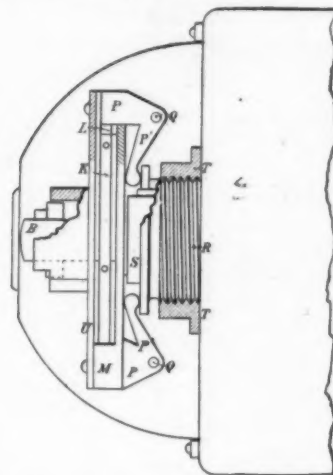


FIG. 8.—DETAIL OF REWINDING CLUTCH OF EVER-READY SELF-STARTER.

B, Extension of main shaft. *K*, Member carrying centrifugal dogs. *L*, Clutch dog. *M*, External member. *P*, *P*, Bellcrank levers. *P*, *P*, Bellcranks on driven member of rewinding clutch. *Q*, *Q*, Bellcrank pivots. *R*, Traveling sleeve on spring arbor. *S*, Spring arbor. *T*, Threaded bushing secured to casing. *U*, Plate secured to *M* which carries a hollow shaft at its center to which a crank can be attached for rewinding by hand when necessary.

engage with the motor shaft by means of the jaw clutch, *A*. By means of lever *M*, the starting crank can be engaged when desired.

In Fig. 3 is shown a side view of the Wilkinson self-starting device as used on the Holmes car, which has a double-opposed-cylinder engine placed lengthwise of the car beneath the bonnet. Fig. 4 shows a horizontal section through the crankshaft, and a plan view of the starter as fitted to a vertical 4-cylinder engine. The flywheel, *A*, has an annular recess, *C* (Fig. 4), over which fits a circular plate, *P*, which

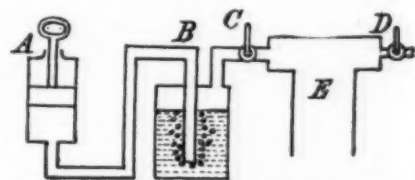
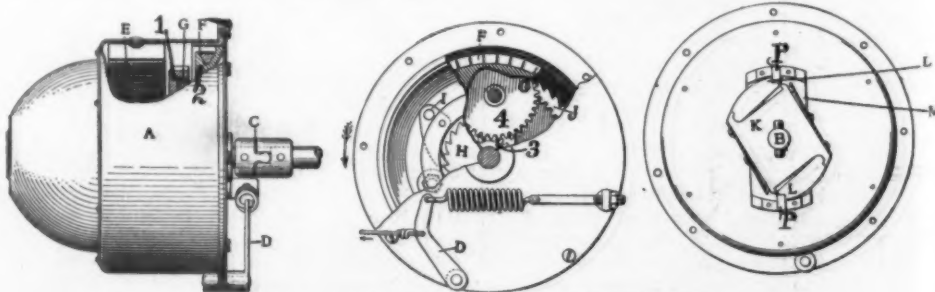


FIG. 9.—THE MORS STARTING APPARATUS.

turns on an annular bearing concentric with the crankshaft. On this circular plate, at *D*, is pivoted the end of a curved lever, *E*, that operates a double cam, *D*, which fits in the groove, *C*, of the flywheel, as shown in Figs. 3 and 4. A pin, *O*, on lever, *E*, fits loosely in a hole in plate, *P*, and acts as a pivot for the lever when the same is returned to its initial position. The semicircular lever, *E*, has a pin at its other end, to which is fastened a curved rod, *I*. *E* is made to rotate the flywheel by the hand lever, *L*, or by the



FIGS. 5, 6 AND 7.—EVER-READY SELF-STARTER.

A, Outer shell or casing. *B*, Extension of engine crankshaft. *C*, Flexible coupling of shafts. *D*, Clutch release lever connected to pedal. *E*, Section of main spring. *F*, Disk with external ratchet teeth. *G*, Disk carrying pawls to engage teeth in disk *F*. *H*, Band clutch to hold disk *F*. *I*, *J*, and *K*, Cycloidal reducing gears. *H*, Starting ratchet secured to shaft. *I*, Starting pawl secured to disk *F*. *J*, Rewinding internal gear and ratchet. *K*, Rewinding clutch. *L*, Centrifugal dogs. *M*, External member of rewinding clutch. *P*, *P*, Movable ends of bellcranks for releasing dogs.

foot lever, *F*, through a connecting rod, *J*. The spring, *K*, returns the lever, *H*, to normal position when released. Neither the cam, *D*, nor the plate, *P*, is normally in contact with the flywheel, so that there is no friction when the engine is running.

Upon releasing lever *H*, spring *K* will tend to return it to its normal position. This will rotate lever *E* about its pivot, *D*, in a clockwise direction, and will also revolve plate *P* about its axis in the same direction. In the case of a "back kick," the spring,

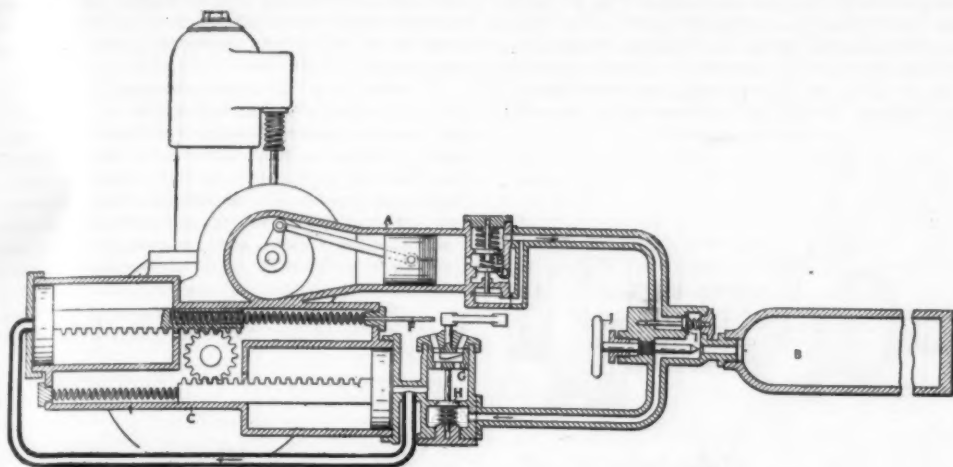


FIG. 10.—RENAULT'S MOTOR STARTER.

A. Air compressor, B. Storage tank, C. Starting motor, D. Suction valve of compressor, E. Delivery valve of compressor, F. Rod for mechanically opening inlet valve H and exhaust valve G of the starting motor, I. Check valve in line from compressor to storage tank, J. Hand-controlled needle valve of storage tank.

In operation, when the lever, *H*, is moved either by hand or foot, it first causes the lever, *E*, to turn on its pivot, *D*. This makes the cam, *D*, wedge against the sides of the groove, *C*. As lever *E* cannot then turn any more on pivot *D*, further movement

K, is depended upon to give an acceleration to the parts *H*, *I*, *E*, and *D*, which is additional to that given by the flywheel. This additional acceleration, combined with the natural reflex action of the operator, causes these parts to move faster on their re-

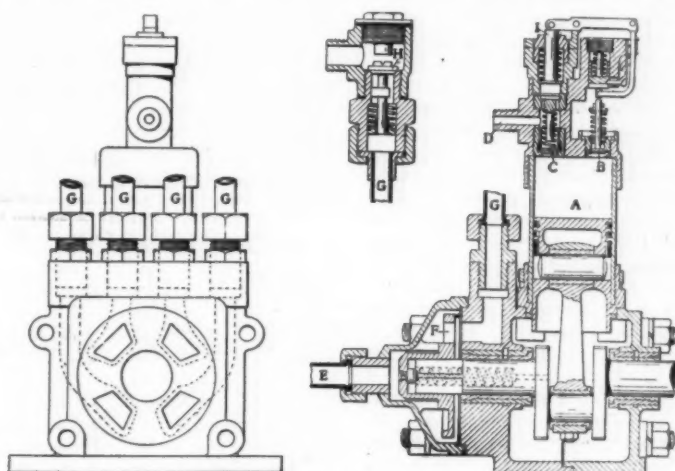


FIG. 11.—DETAILED VIEW OF LE TOMBE SELF-STARTER.

A. Air compressor cylinder, B. Inlet valve, C. Delivery valve, D. Air outlet from compressor, E. Air connection from tank to distributor, F. Distributor disk, G, G. Air tubes to motor cylinders, H. Check valve at entrance to cylinders, I. Automatic relief valve.

of *H* has precisely the same effect as if *J* were a fixed crankpin, and the flywheel will be revolved about its axis by the connecting rod, *I*. By this means a fresh charge will be compressed and fired in one of the cylinders, so that the engine will start.

turn motion than the flywheel tends to drive them, it is claimed, so that the lever, *E*, turns about its pivot and releases the cam, *D*.

Naturally, after a time, some one thought that the motor, while running idle, might be made to store

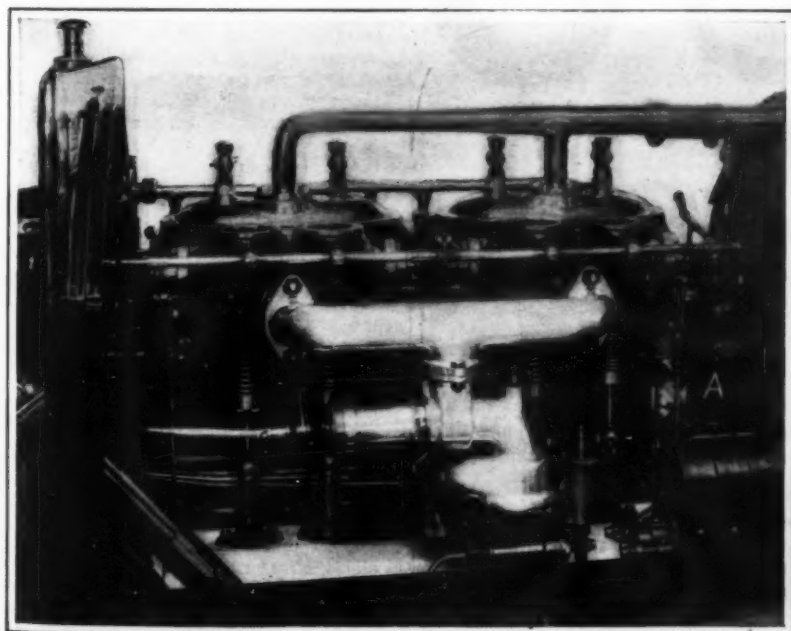


FIG. 12.—THE FIAT SELF-STARTER. A IS THE WATER-JACKETED PUMP CYLINDER.

up power to start itself, and several devices of this kind have been brought out, one of the most successful being the "Ever-Ready" self-starter. This device is shown in Figs. 5, 6, 7, and 8. The main spring, *E*, which furnishes the motive power, has its outer end secured to the casing of the device and the inner end attached to a hollow arbor. This outer arbor incloses a second hollow arbor, which in turn surrounds the shaft, *B*. This shaft is a continuation of the engine crankshaft. To the front end of the spring arbor is secured a disk, *1*, on the outside of which are cut

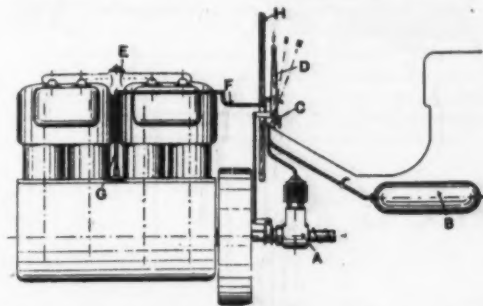


FIG. 13.—GENERAL ARRANGEMENT OF THE SAURER SELF-STARTER.

A. Air compressor pump, B. Steel air reservoir, C. Pressure valve, D. Handle for operating pressure valve, E. Distribution valve, F. Air pipe from pressure valve to distribution valve, G. Vertical shaft of rotating distribution valve, H. Dash.

ratchet teeth, *J* (Fig. 6), while in a recess on the front of this disk is cut an internal gear. Pawls on the back of another disk, *2*, engage the ratchet teeth, *J*. This disk, *2*, is normally held stationary by means of a hand brake, *F*, which, however, may be released by a movement of the lever, *D*, to the left. In case of such release, disk *1*, driven by the spring, *E*, rotates disk *2* by means of the pawls in engagement with the teeth, *J*. Disk *2* in turn drives the ratchet wheel, *H*, by means of the pawl, *I*. Ratchet *H* and pawl *I* are on the front of disk *2*, the ratchet being secured to the shaft, *B*.

Surrounding *B* is a sleeve which carries at its front end a pinion, *3*, that meshes with a gear, *4*, secured to the disk, *2*. Behind gear *4* is another small pinion that engages the internal gear, *J*, of disk *1*. This system of gears causes the disk, *1*, to revolve in a direction opposite to that of the center pinion, *3*, ten revolutions of which causes one revolution of the disk *2*. To the rear end of the bushing is secured the driven member, *M*, of the rewinding clutch (Fig. 7). The driving member of the clutch, *K*, is secured to the shaft, *B*, and has weighted dogs, *L*, which are thrown out by centrifugal force when the motor has attained a certain speed. These dogs engage the points, *P*, of the driven member. Thus the main spring is rewound through the train of planetary gearing. When the spring has been rewound a certain

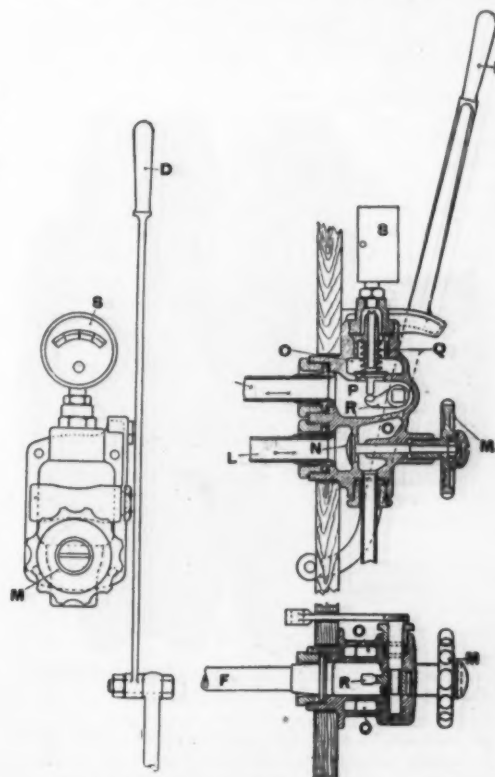


FIG. 14.—PRESSURE CONTROL VALVE.

D. Operating lever, F. Outlet pipe to distribution valve, L. Inlet air pipe to pressure valve, M. Hand wheel of stop valve, N. Stop valve, O. Air ports from stop valve to pressure control valve, P. Pressure control valve, Q. Helical spring to return pressure valve on its seating, R. Arm of rocking lever, S. Pressure gage.

number of turns, the projections, *P*, are moved outward so as to clear the dogs, *L*, thus disconnecting the winding train from the shaft, *B*. The arrangement by which this is accomplished is shown in Fig. 8.

Sliding on the hollow arbor, *S*, to which the spring is secured, is a sleeve, *R*, which is feathered on *S*. A thread is cut on the outside of this sleeve, and this fits a corresponding thread in a bushing, *T*, se-

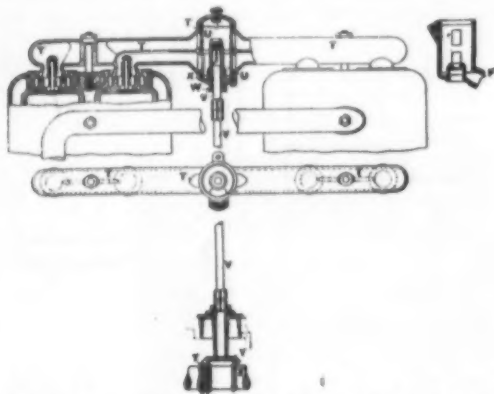


FIG. 15.—SHOWING ARRANGEMENT IN SIDE ELEVATION, END ELEVATION, AND PLAN OF THE DISTRIBUTION VALVE MECHANISM AND CONNECTIONS.

F, Pipe connection with pressure control valve. *T*, Main casting, comprising valve chamber and communication to cylinders. *U*, Rotating distribution valve. *V*, Vertical shaft for driving same. *W*, Gland through which the vertical shaft runs. *X*, Metallic gland packing. *Y*, Bevel gear for driving vertical shaft. *Z*, Crankshaft of engine.

cured to the casing of the device. When the spring is wound, the sleeve is forced to the left, and when the spring is unwound, the sleeve is moved to the right. When the spring is wound a certain number of turns, the end of bushing, *R*, forces the ends of the bell-crank levers, *PP'*, to the left, so that the bell-cranks turn about their pivots, *QQ*, and the ends, *P, P'*, are moved out of the path of the rewinding dogs, *L* (Fig. 7), thus disconnecting the two members of the rewinding clutch. When the spring unwinds, the bell-crank levers are returned to their normal position by springs, the sleeve, *R*, moving a sufficient distance to the right. A plate, *U*, is secured to the driven member of the rewinding clutch through the center of which the shaft, *B*, projects. This is surrounded by a collar whose end is cut to form one member of a jaw clutch, the other member being formed by the hollow shaft of a detachable rewinding crank. This crank is provided with a telescope piece, by means of which the motor may be turned over in the ordinary way, this piece being extended and engaged with the shaft, *B*. It is therefore possible to rewind the starting device, in case it is run down, or to start the motor by cranking in the ordinary way.

Interest in self-starting devices, until the past year, rather died out owing to the fact that a four-cylinder car fitted with coil and battery ignition can generally

of gas and air into the motor cylinders by outside means, and then ignite this charge by the regular or a supplementary ignition system. A simple device of this sort is used on some of the Mors cars, on which low-tension magneto ignition is employed. This device is shown diagrammatically in Fig. 9. It consists of a manually-operated air pump, *A*, of ample proportions, which forces air through a surface or filtering carburetor, *B*, and thence through admission cocks, *C*, to all of the cylinders, the relief cock, *D*, being opened, so that the carbureted air drives the

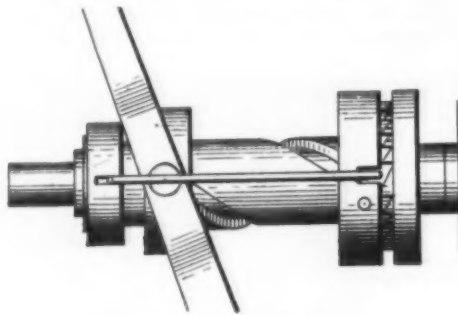


FIG. 16.—THE MILNE STARTER.

original contents of the cylinders out before it. When this arrangement is installed, a supplementary coil and battery system is employed.

Another example of this method is employed on the Harrison crankless car. In this case a mixture of acetylene gas and air formed under pressure in a mixing tank is employed. This mixture is definitely proportioned by measuring the amounts of gas and air admitted by means of a pressure gage. The gas is admitted only to those cylinders all of whose valves are closed. This is done through a four-way cock, which is combined with an indicating switch in the ignition circuit, so that the proper position of the cock can readily be ascertained. This device has the advantage that it requires no alteration in the motor for its application, and the pump which compresses the air can be used to inflate the tires. The acetylene gas is also used in the headlights.

Compressed air or gas stored in a suitable tank and used expansively for starting the motor seems to be coming to the fore, whether used directly in the engine cylinders or in an outside starting device. A good example of the latter system is that employed on some of the Renault models. This apparatus is shown in Fig. 10. A pump, *A*, driven by the motor is used to compress air in the tank, *B*, from which it is admitted to the starting cylinders, *C*, by a form of three-way cock. The starting pistons revolve the motor shaft by means of racks acting on a pinion, which is secured to the motor shaft by a ratchet clutch.

A more usual method is to use some or all of the motor cylinders for starting. This is accomplished in the new Triumph car as follows: Shifting the camshaft longitudinally transforms two of the cylinders

normal position, and the first two cylinders take up their regular work. The compressed gas for starting is obtained through a relief valve on the rear cylinder, which is set to open at a pressure exceeding the maximum compression. The two inlet valves of the forward cylinders are of the poppet type, but have pistons which counterbalance in a measure the pressure of the air, which would otherwise tend to force them open.

A method that has lately come into use with compressed air as a starting medium is the use of all of the engine cylinders as starting cylinders, but only on their working strokes. Since the pressure of the air used is not more than about 150 pounds, it will be seen that as soon as a cylinder picks up its cycle the air will not interfere with this operation, since the setting of the regular inlet and exhaust valves is not interfered with by the special starting valves employed. This method is used on the De Dietrich, F. I. A. T., and Isotta Fraschini cars, on which a pump driven by the engine is employed to compress air in a reservoir.

An ingenious application of this method is seen in the Letombe self-starter, which, together with the pump, is practically self-contained, and can be applied to any car without alteration of the motor, provided there is room for the device under the bonnet. The pump is driven at the same speed as the camshaft. Detailed drawings of this device as applied to a De Dietrich car are given in Fig. 11. Check valves are placed in the air pipes close to the cylinders to prevent "back-firing." The distributor valve is of the rotating slide-valve type, and is normally kept off its seat to prevent undue friction, but when the air valve is opened, it is forced to its seat by the rush of the air in the pipe, *E*.

In the F.I.A.T. self-starting device (Fig. 12) the pump cylinder, *A*, is water-jacketed, and is located in front of the forward cylinder of the engine, where it is driven from the crankshaft. The air valves are brought into action by shifting the exhaust-valve camshaft longitudinally, which also partially relieves the compression through the exhaust valves on the compression stroke. The air valves are secured to the sides of the exhaust-valve pockets. The motor picks up its cycle very quickly with this type of starter, and appears to the observer to start on the spark.

A very recent addition to the compressed-air type of self-starting appliances was brought out in Europe by Herr Hippolyte Sauer. This is shown attached to a motor in Fig. 13, and in detail in Figs. 14 and 15.

A small air compressor, *A*, Fig. 13, with flanges on the cylinder to radiate the heat liberated, is driven by engagement with the crankshaft through a clutch operated by the lever, *D*. This pump compresses air in the steel reservoir, *B*, to a maximum pressure of about 370 pounds to the square inch. By means of a special valve, the compressed air is admitted through a rotating valve to the engine cylinders, and causes the motor to start. The steel bottle, pump, and other parts of the apparatus are tested by hydraulic pressure to nearly double their necessary strength.

The control lever, *D*, has several functions. In first position it connects the pump with the engine shaft and closes valve, *P* (Fig. 14), so that the air that is pumped passes into the tank through the pipe, *L*. In the second position the lever disconnects the pump, and in third position it opens the valve, *P*, by means of rocking arm, *R*, to permit the stored air to pass through pipe, *F*, to the cylinders. The handwheel, *M* (Fig. 14) controls the valve, *N*, which, when shut, prevents air from entering the working valve through passages, *O*. The pipe, *F*, conducts the air to the head of the engine, where there is a special casting, *T*, shown in Fig. 15. At the middle of this casting is a rotating valve, *U*, which has four ports coinciding with passages leading to the four cylinders. The valve is rotated by means of bevel gears, *Y*, and rod, *V*, from the engine camshaft, and is timed so that the port is always open to the cylinder that is on the working stroke. As the engine turns over, the ports are uncovered successively. When the first piston finishes its working stroke the port closes, and the air in the cylinder is released through the exhaust valve, while the port to the next working cylinder opens. No means is provided for relieving compression on the compression strokes of the pistons, this being ignored because the air pressure is sufficiently in excess to make it a negligible quantity.

A reducing valve fitted to the starting device makes it possible to use air from the tank for inflating tires and blowing the horn or siren. At *S* is a pressure-indicating gage that warns the driver when his pressure is getting too low, and when it has again been brought up to the maximum. A pressure of fifteen atmospheres suffices to start the car six or seven times.

Various cars made on the so-called combination system, using both gasoline and electric motors, have a small storage battery so arranged that the dynamo generally driven by the gas engine can be used temporarily as an electric motor to start the engine. Among these may be mentioned the Gas-aulec and the Fischer



FIG. 17.—THE KANE STARTING DEVICE COMPLETE.

be depended upon to start upon turning on the switch if it has been stopped with a fresh charge of gas under compression. However, the introduction of high-tension and low-tension magneto ignition and of six-cylinder and eight-cylinder motors, which require some strength and dexterity to start on the magneto alone, has done much to revive interest in the subject.

One method now employed is to introduce a charge

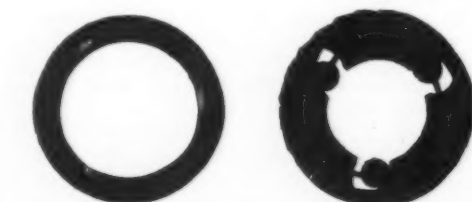


FIG. 19.—WEDGE CHAIR FOR RELEASING ROLLS OF MAIN RATCHET.



FIG. 20.—SECONDARY RATCHET OF THE KANE STARTER.



FIG. 18.—MAIN RATCHET ON SHAFT OF THE KANE STARTER.

into air cylinders by bringing into action cams that open the inlet valves on every down stroke and the exhaust valves on every up stroke. The same lever which accomplishes this also acts on a double valve, which cuts off the two cylinders from the carburetor and connects them to a compressed-air reservoir. When the engine has been turned over a couple of times by these cylinders, the other two cylinders begin to act. Then the starting lever is returned to its

combination systems, both American inventions.

Two new self-starting devices have been brought out very recently in Detroit, one by the Milne Auto-Start Company and the other by the Kane Starting Device Company. The Milne starter is very simple, as shown in Fig. 16. It consists of a steel sleeve mounted on an extension of the crankshaft, or, in a launch, on the propeller shaft, and having a double quick-pitch channel in which engage two rollers secured on the inside of a sliding collar pivoted in a bifurcated lever. Ratchet teeth cut on the face of a ring at the right end engage with corresponding teeth cut in a collar secured to the shaft. When the lever is drawn backward, the entire sleeve is turned, the shaft being rotated with it through the engagement of the teeth. When the motor starts, the teeth back the sleeve away out of engagement. There is said to be no danger from back-firing, as means is provided for friction

release in such an event. The device is but 6 inches long, and weighs complete only 12 pounds. The starting lever can be placed in any convenient position on the car.

The Kane starting device is shown complete in Fig. 17, and its principal parts in Figs. 18, 19, and 20. The mechanism is intended to be attached at the end of the crankshaft and concealed from view. It is operated from the driver's seat by a lever conveniently placed. The principle made use of is that of the bicycle free-wheel clutch. The device consists of two roller ratchets having a releasing wedge piece between that comes into action in event of a back kick. The main ratchet (Fig. 18) carries three steel rollers in cam-faced pockets so cut that when the ratchet or clutch is turned on the crankshaft in one direction, the rollers wedge and cause the shaft to turn also. As soon as the engine is started by this action, the

shaft turns faster than the ratchet, and the rollers are released. The slightest backward motion of the crankshaft also releases the grip on the shaft. The secondary ratchet, Fig. 20, has an inner member and an outer member, each provided with teeth that correspond.

The outer member is prevented from turning by pins, but reverse action of the motor moves the inner member of the secondary ratchet and causes the teeth to be forced apart, driving the outer member toward the main ratchet, and forcing the wedges behind the rollers so as to release them. When the reverse action of the motor ceases, the wedge ring is returned to normal position by springs operating between the ring and the main ratchet to force the secondary ratchet back to its place. On account of this special releasing device, a back kick of the engine cannot do any damage.

THE PRESERVATION OF TIMBER.

SOME NEW DATA ON PENETRATION.

HAVING regard to the more or less problematical character of the protection afforded by various processes intended for the preparation of timber, the Administration of the State Railways of France decided to make a systematic investigation into the whole subject. For this purpose they enlisted the services of Prof. H. Devaux, of the Faculté des Sciences de Bordeaux, and M. H. Bouygues, D.Sc., to conduct the necessary experiments. Although the inquiry has not yet been completed, some instructive results have been obtained with regard to the penetration of heat into timber during the process of treatment.

In the present state of knowledge it is an open question whether parasitic growths, feeding upon and destroying the living tree, continue to live in and upon timber after it has been cut and applied to structural work. It is generally recognized that wood, consisting chiefly of cellulose practically indestructible under ordinary conditions, only suffers decomposition in the presence of sap or sap residues containing diastatic ferments and parasites. The absolute sterilization of all living organisms in timber is consequently a necessary prelude to the injection of merely antiseptic substances, which rarely penetrate for more than a short distance beneath the surface. Moreover, if in timber that has been treated, cracks appear which penetrate to interior parts neither sterilized nor impregnated, the door is at once opened to destructive agencies in spite of the preservative treatment upon which reliance has been placed.

In nearly every process for the preservation of timber, heat is applied in one way or another with the object of effecting sterilization. In some cases the material is submitted to the action of steam, in others to that of hot air, and in others again it is immersed in a hot solution of the antiseptic substance. Admitting that steaming or other means of applying moist heat is useful for softening and distending the fibers so as to facilitate absorption of the antiseptic liquid, we must not lose sight of the fact that sterilization is a still more desirable object. Consequently the penetration of heat into timber properly constitutes the first object of study in any inquiry into preservative methods.

MM. Devaux and Bouygues commenced their investigations by submitting to the action of heat, cylinders of maritime pine, some consisting of sap-wood and others of heart-wood. All the cylinders were 15 3/4 inches long and of diameters ranging from 1.89 inches to 4.92 inches. When the cylinders were placed in saturated steam at 212 deg. F., the temperature of the wood slowly increased, the rate of increase became rapid at from 176 deg. to 194 deg., and then again became slow, the temperature of 212 deg. being attained only after a considerable lapse of time. For the larger cylinders under examination the temperature of 208 deg. was not reached until the timber had been in the steam for six hours. Between 95 deg. and 131 deg. the temperature curves for all the cylinders approached sensibly the form of a straight line, thus permitting comparison of the time required for the penetration of heat into cylinders of various diameters.

Table I. gives the observed and calculated results obtained by MM. Devaux and Bouygues for cylinders of various diameters between the temperatures of 95 deg. and 131 deg. F.

From this table it will be seen that the time required for the penetration of heat into a cylinder may be taken without serious error as being inversely proportional to the square of the diameter. This conclusion is interesting from the theoretical standpoint because it agrees very fairly with the theory of Fourier on the penetration of heat through homogeneous cylinders, and still more interesting from the practical point of view, because it affords a direct clue to the relative rate of heat penetration into timber cylinders of different diameters. During the process of steam-

ing, water was absorbed by the timber to a considerable extent, especially in the cylinders of sap-wood, the proportionate volume of water increasing with reduction of diameter. This result is obviously due to the same causes as those which govern the penetration of heat. Owing to the low conductivity of air, and the still lower conductivity of woody fiber, the

pine cylinders to the action of superheated steam at the temperature of from 266 deg. to 338 deg. F. Notwithstanding the high temperatures thus provided, it was found difficult to heat the timber up to 212 deg. F. at the center of the specimens tested, even after prolonged exposure.

This result can easily be accounted for by the ex-

TABLE I.—THE PENETRATION OF HEAT INTO PINE CYLINDERS FROM SATURATED STEAM AT 212° F.

Sap-wood.				Heart-wood.			
Diam. <i>d</i>	Duration of Heat <i>t</i>	Value of $\frac{t}{d}$	Value of $\frac{t}{d^2}$	Diam. <i>d</i>	Duration of Heat <i>t</i>	Value of $\frac{t}{d}$	Value of $\frac{t}{d^2}$
Inches.	Minutes.			Inches.	Minutes.		
1.89	4.3	2.27	1.20	1.89	5.1	2.70	1.43
2.72	6.7	2.46	0.90	2.72	9.0	3.31	1.22
3.35	11.0	3.28	0.98	3.35	14.9	4.45	1.33
4.13	18.4	4.46	1.08	4.13	23.9	5.78	1.40
4.92	26.4	5.37	1.07	4.92	30.4	6.18	1.25

penetration of heat into timber during the process of steaming would be exceedingly protracted were it not for the condensation following the emission of latent heat that takes place as the steam comes into contact with the relatively cold material, and the more rapid conduction of heat through the water of condensation absorbed by the timber. This sequence of operations—condensation, absorption, and conduction—is continually repeated in timber surrounded by saturated steam, and the rapidity of heat penetration is in proportion to the rapidity of condensation and the readiness with which water is absorbed. Moist timber should be more rapidly heated to the center than dry timber, because water is a better conductor of heat than air. The accuracy of this view is confirmed by the results contained in Table I.

MM. Devaux and Bouygues do not appear to have made any investigation into the effect of apparatus designed to extract occluded air before heating the timber by steam. We certainly think they would do well to extend their researches in this direction, as it is very probable that they would find a marked increase in the rate of penetration through timber after the removal of air by a simple vacuum apparatus, such as that employed in steam disinfection chambers.

In Table II. we give some figures relative to the weight of water actually absorbed by some of the cylinders tested.

TABLE II.—ABSORPTION OF CONDENSATION WATER BY TIMBER DURING THE STEAMING.

Diam.	Duration of Heating.	Weight of Timber.		Water Absorbed.
		Before Test.	After Test.	
In.	Minutes.	Lb.	Lb.	Lb.
1.89	Sap-wood 40	0.91	1.03	0.12
4.92	208	6.38	6.90	0.52
1.89	Heart-wood 52	0.86	0.884	0.024
4.92	303	6.05	6.292	0.242

Bearing in mind the proportion of water absorbed as the result of treatment by saturated steam, we see that in processes where the injection of antiseptic solutions is preceded by steaming, the increased weight of the treated timber must not be attributed entirely to the absorption of the preservative material.

Similar experiments were conducted by exposing

tremely slow conductivity of superheated steam, which does not begin to act as a really efficient heating medium until it has been more or less slowly reduced to the state of saturated steam by the transfer of heat to the colder objects with which it may be in contact. After reduction in this way heat is more rapidly conducted through the water of condensation. It would have been interesting if the investigators had made tests with saturated steam at temperatures equal to those of the superheated steam, for the purpose of comparison.

A third series of tests with air at the temperature of 284 deg. F. indicated a far slower rate of penetration than that obtained by the employment of steam, thus demonstrating the well-known inefficiency of hot air for heating substances in the manner here considered.

MM. Devaux and Bouygues subsequently made tests upon pine railway sleepers, some green, some dry, others consisting chiefly of sap-wood, and others again chiefly representing heart-wood. For six specimens submitted to the action of saturated steam at 230 deg. F. for sixty minutes, the temperatures in the middle of the wood were 80.6 deg., 91.4 deg., 93.2 deg., 101.3 deg., 102.2 deg., and 113 deg. F. These variations are very marked, but it was found after prolonging the steaming process for ninety minutes that the maximum interior temperature in no case exceeded 111.2 deg. F., while after steaming for sixty minutes the temperature never reached 122 deg. F., at the depth of from 4 centimeters to 5 centimeters below the surface. In every case, whether the sleepers were green or dry and whether they consisted chiefly of sap-wood or of heartwood, there was always an increase of weight owing to the absorption of condensation water, the amount of water absorbed varying from about 0.5 pound to 1 pound for sleepers weighing from about 110 pounds to 154 pounds each.

The investigators also observed the increase of temperature in pine sleepers during treatment by the process adopted in the State Railway Works at Saint-Mariens. The sleepers were placed for a period of from thirty to fifty minutes in saturated steam at 230 deg. F.; pressure was next relaxed and maintained for forty minutes at the point corresponding with a partial vacuum of 2.36 inches of mercury. Then a mixture of creosote and chloride of zinc, heated to 176 to 194 deg. F. was introduced, and when the chamber was completely filled the pressure was increased to 85.3 pounds per square inch, and so maintained for from twenty to twenty-five minutes. The maximum temperature attained in the middle of the sleepers ranged from 114.8 deg. to 122 deg. F. for timbers consisting chiefly of heartwood, and from 125.6 deg. to 131

deg. F. for timber consisting chiefly of sap-wood. By prolonging the process so that the partial vacuum and the compression each extended to the period of sixty minutes, the temperatures increased to 149 deg. F. for a sleeper chiefly of heartwood, and to from 149 deg. to 158 deg. for three sleepers chiefly of sap-wood. By the preservative method cited above the temperature attained in the interior of the sleepers was in no case very high, only exceeding 140 deg. F. under quite exceptional conditions that are never realized in ordinary practice, and as a general rule the interior temperature was in the neighborhood of 122 deg. F.

These facts being satisfactorily established, we are justified in arguing that as absolute sterilization cannot be assured at temperatures below 240 deg. F., the temperatures reached in the interior of timber during treatment by the process here in question—and by other processes of similar character and with similar temperature limits—cannot possibly insure the sterilization of destructive organisms. It may be the fact that the outer portions of the timber are protected by the antiseptic liquid absorbed, but the inner portions to which the antiseptic does not penetrate are not benefited. If spores exist in such parts they cannot be

killed by the inadequate temperatures given by low-pressure steam, and their activity is not reduced by the antiseptic substances ordinarily used, owing to the failure of the liquid to penetrate to a sufficient distance beneath the outer surface of the wood.

To insure absolute sterilization the timber must be heated throughout—preferably by saturated steam—to the temperature of at least 240 deg. F., and this temperature must be maintained for not less than fifteen minutes, or the timber must be completely saturated with a solution capable of destroying living organisms and spores.—The Builder.

COPPER REFINING MACHINERY.*

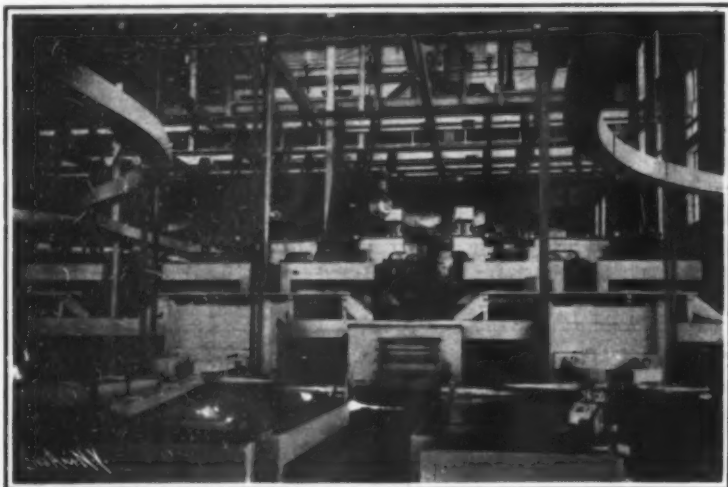
HOW ORE IS HANDLED BY INGENUOUS MACHINERY.

BY DAY ALLEN WILLEY.

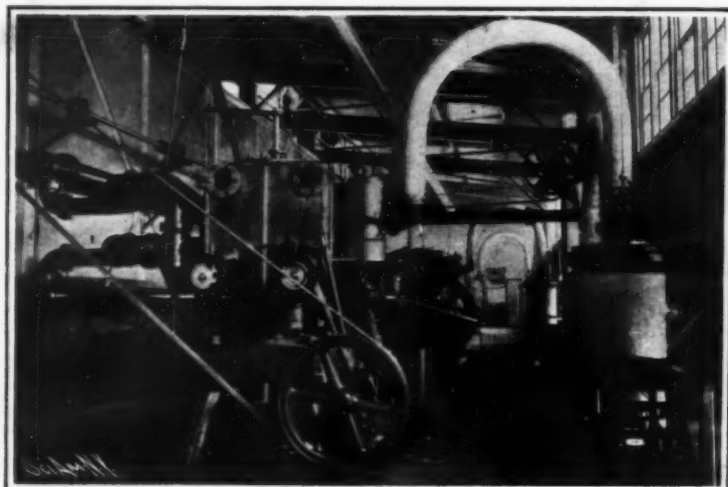
THE copper-bearing ores of the United States are mined principally in three sections of the country—on the Keweenaw peninsula of Michigan adjacent to Lake Superior, in Montana, and in Arizona. So ex-

the methods employed in earlier times in extraction of the metal. It may be needless to say that the stamp mill exerts its force through a mass of iron or steel which falls upon the ore, crushing it into small

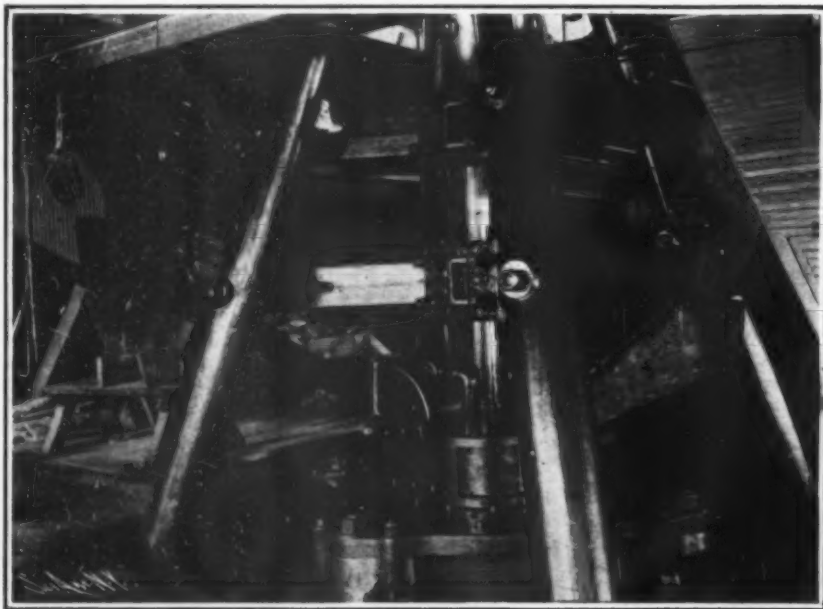
The more modern type of jig is usually a revolving screen, which by its movement separates the material into different sizes, when it is carried into launders. This name is appropriate, since through



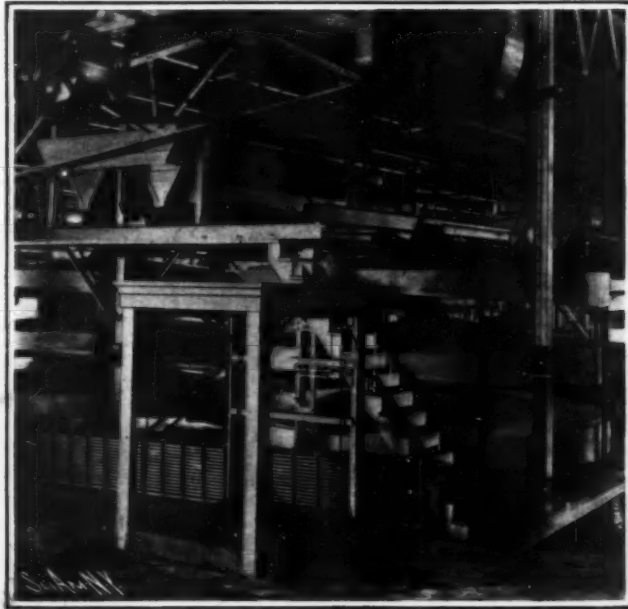
GENERAL INTERIOR VIEW OF ORE-SEPARATING PLANT, SHOWING CONVEYORS AND JIG.



HEADS OF ORE CRUSHERS IN A MICHIGAN MILL.



FEEDING A GYRATORY CRUSHER FOR TREATING ORE.



REVOLVING SIZING TABLES IN MILL.

COPPER REFINING MACHINERY.

tensive is the Lake Superior production, that from this region comes fully 25 per cent of the copper output of the United States. The Calumet and Hecla plant alone crushes over 6,000 tons of ore daily.

As much of the copper is found in formation containing silver, sometimes gold, the machinery designed in recent years for separating the metals has been arranged with a view of reducing the percentage of waste to a minimum. From the time the metal is taken from the mine in the form of ore until it is freed from all foreign matter, it is subjected to several processes which may be embraced in two distinct groups. One is its preparation for the smelter, while the other comprises the smelting and refining. Although several inventions have been perfected for reducing and concentrating the ore, the preliminary processes are not radically different in principle from

fragments and powder. Mechanical power is only employed in the stamp mill to lift the crushing head, as it acts by the force of gravity. In its operation the stamp mill resembles the familiar pile driver, the stamp descending through a groove. The stamp is the principal process employed for the first crushing, although in some districts in Michigan the gyratory mill has been introduced. As a rule, however, this process is more expensive unless steam or hydraulic power can be obtained at a very low cost. Prior to passing through the stamp mill, the ore is first assorted by being fed from the storage bins or mine cars upon screens composed of iron bars set about one inch apart. The material which falls through these "grizzlies" or "fines" passes directly upon what are really the first set of jigs. The ore which remains upon the "grizzlies" is conveyed to the stamp or gyratory mill, lumps too large to be taken in by the mechanism being broken up by sledge hammers,

the launders flows a current of water diluting the material as it passes to the next set of jigs. These consist of beds of sand held by screens moved by currents of water passing upward and downward. Another form of jig is a screen which is also movable, but pushed up and down in a tank of water. In either case the operation separates the ore according to its specific gravity. A further separation, however, is accomplished by treating the powdered ore on circular tables. As these revolve, a film of water flows over their surface. This last operation of "sizing" generally removes most of the waste material which may remain. It is carried away in solution, leaving the mineral in the form of powder or concentrate.

While the Calumet and Hecla plant is notable for its enormous capacity, that at the Anaconda works in Montana is also one of the largest in the world. One series of six stamps alone has a crushing capacity

* Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

of nearly 2,000 tons daily. Each stamp shoe weighs 500 pounds, yet such is the extent of abrasion caused by contact with the ore, that frequently they must be replaced after a service of but three days. These stamps are among the most powerful in the country, the total crushing weight exerted by each being no less than 30 tons. At the Michigan plant the concentrating machinery is entirely separate from the

crushers. As fast as the material passes through the stamp mill it is transported to Lake Linden, a distance of four miles, where it is reduced to concentrates.

As in the modern coal breaker, advantage is taken of the force of gravity in handling the ore through the various processes. The grizzlies are usually placed at a considerable elevation above the other appar-

atus, so that the "fines" will pass by gravity to the first series of separators, and the larger fragments can be conveyed to the stamps in the same way. The product of the stamp mills is taken to the jigs by means of inclined conduits, so that when the copper is ready for the smelter, it has passed successively from the top to the bottom of the plant where it is being treated.

A NEW MOUNTAIN LOCOMOTIVE.

AN IMPROVED SYSTEM WITH INCREASED ADHERENCE.

A SYSTEM of traction which is designed specially for use upon heavy grades has been brought out in France within a recent period. The principal feature of the system is the use of a type of locomotive in which a third rail lying between the main rails of the track is clasped between wheels or rollers which thus serve to give an increased adherence to the locomotive and in this way a comparatively heavy train can be taken up a steep grade.

Speaking of different methods which are in use at

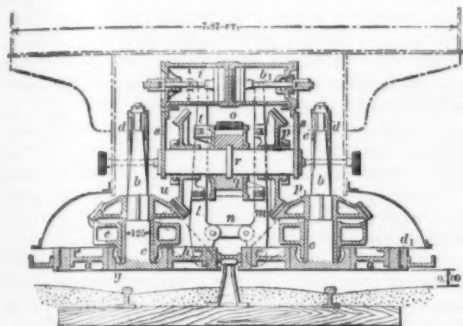


FIG. 1.—SUPPLEMENTARY ADHERENCE MECHANISM.

present, we find that a locomotive provided with a tender is used oftentimes upon the main trunk lines, and in this way it is possible to draw a weight representing two or three times the weight of the engine upon grades of 2.5 or 3 per cent. In the case of a locomotive tender we may find that the locomotive is able to draw an amount equal to its own weight up a 5 per cent grade. Coming to electric traction, where

motor cars are used which generally have a light weight, the limit of the grade may now reach as high

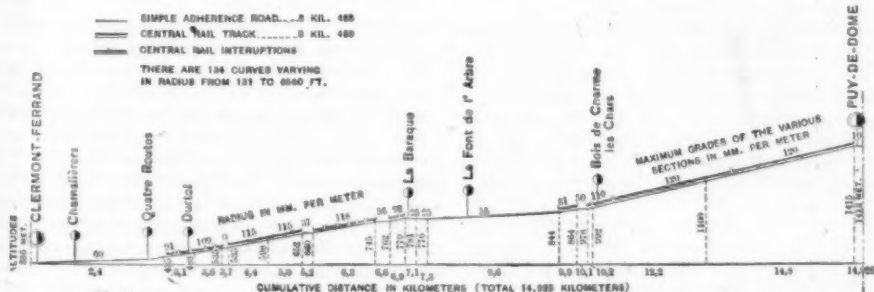


FIG. 2.—LONGITUDINAL PROFILE OF THE PUY DE DOME ROAD.

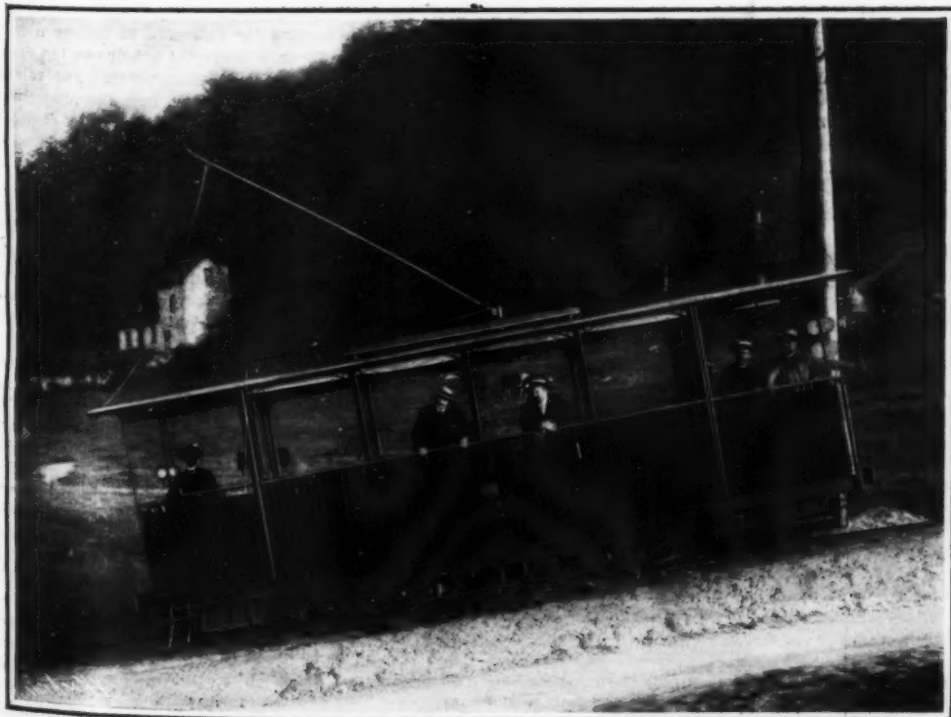


FIG. 3.—ONE OF THE PUY DE DOME TROLLEY CARS. NEW LOCOMOTIVE SYSTEM.

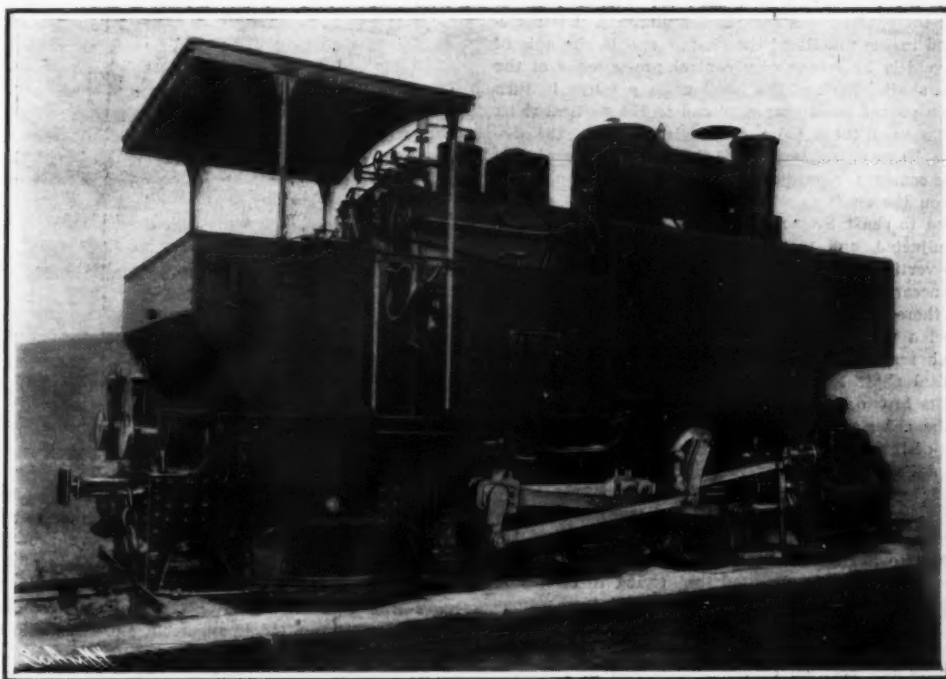


FIG. 4.—LOCOMOTIVE OF THE PUY DE DOME ROAD.

as 12 per cent, this depending upon the condition of the rails to a large extent. When the grades exceed the preceding limits, traction by simple adherence becomes difficult if not impossible. We must therefore have recourse to a method which will increase the adherence which is not sufficient here. One method is to use the rack-rail system which is largely employed for incline tracks, with the pinion working either upon a steam or electric locomotive or motor car. A second method which is not so widely employed and which will be illustrated in the following description, consists in replacing the rack-rail of the track by a central rail fixed by a series of high supports or brackets to the ties, and having two rail heads which are adapted to receive two horizontal wheels operated by the motor. The wheels are pressed against the central rail at each side with a sufficient pressure to produce the needed extra adherence, thus making up the amount which the running wheels are no longer able to furnish. One of the early trials of such a system was made between 1864 and 1869 by Fell upon a temporary section of track with grades of 8 per cent which was to be operated at Mont Cenis between Saint-Michel and Suze by means of steam locomotives, during the execution of the tunnel. These locomotives, besides some defects of construction, showed two leading disadvantages. Owing to the stiffness of all the parts designed for extra adherence in relation to the locomotive truck, resistances of considerable value were produced when the middle rail was slightly displaced from the exact center of the track and especially in the curves. This gave a lessening of the efficiency of the system and a frequent breakage of the motive parts of the horizontal wheel system, especially the rods which connected the steam cylinders with the vertical shafts upon which these wheels were mounted. Moreover, the springs which served to press the horizontal wheels against the rails were difficult to regulate, and the variation in adherence on the central rail according to the slope of the track was almost impossible to carry out. This gave rise to slipping of the wheels which resulted in breakage of the motive parts.

In order to give practical form to the additional adherence on the middle rail, it became necessary to avoid in the first place the two disadvantages mentioned, and thus render the horizontal motive apparatus independent to a large extent of the truck of the motor car or locomotive, by allowing it to follow the variations in position of the middle rail of the track without producing any added resistance therefrom, at the same time keeping the adherence pressure at the right figure. Again, the variation of the ad-

herence is to be varied in a practical way according to the changes in the slope of the track. In order to obtain these conditions the question was taken up by one of the most competent French engineers, M. Hanscotte, of the Fives-Lille Company, one of the large machine and locomotive works of the country. Represented in the sectional view, Fig. 1, is the supplementary adherence mechanism which M. Hanscotte designed for the purpose. Upon a horizontal shaft *r* fixed to the longitudinal beams of the chassis, is a loose pinion *q*, which is worked either by chain or gearing from the motor of the car or locomotive. On the same shaft are also two loose bevel gears *p*, operated by the pinion *q* by means of jointed levers which allow the bevel gears *p* to take any desired position upon the shaft *r*. As regards the pinion *p*, it is maintained in the middle of the shaft *r* and in the axis of the vehicle by means of a central projection *r* of the main shaft. Each of the bevel gears *p* works in turn with a second bevel gear *p*, placed on the vertical shaft *b*. To keep these pairs of bevels in mesh, the distance between centers of their respective shafts is to be constant, regardless of the position of the pinion *p* upon the shaft *r*. For this purpose the pinion *p* is joined to shaft *b* by means of rods whose length can be adjusted, and the rods are fixed to the collar *u*. The vertical shaft *b* is worked by the bevel gear *p*, and accordingly by pinion *q* joined to the motor shaft, and therefore *b* in turn is made to work the adherence wheel *a* which is fixed to the latter at the base and which rests upon the middle rail of the track. The vertical shaft *b*, together with all its working parts, rotates in two bearing collars *c* and *d* which form part of the chassis *e*, the latter resting against the cross rods of the main I-beams of the car, but can nevertheless take a sliding movement from one side to the other by means of rollers mounted upon the cross-bars. Such rollers, as well as the jointed rods of the pinions, annul almost entirely the resistance of the chassis to a transverse movement.

To sum up, it is observed that owing to the transverse motion of the chassis *e* and the pinions *p* upon the shaft *r*, the whole supplementary adherence system can be displaced perpendicular to the track, whatever be the position of the middle rail in reference to the axis of the track, and this without giving any considerable resistance values, as in the case of the above-mentioned Fell system, and also without danger of breaking the parts. It is to be noted that the gears *p* and *p*, are of the chevron or right-angle gear type, cut according to the most recent formulae, and have the advantage of reducing the friction to a minimum. In this way the first disadvantage of the Fell mechanism which we mentioned, that is, the excessive stiffness of the parts used for horizontal adherence with regard to the chassis of the car, is now eliminated. Another point to be noted is that the oil used for lubricating the bearings of shaft *b* falls into a reservoir *g* placed at the bottom of the shaft, whence it runs into the basin *h* forming part of the adherence wheel.

It remains to be seen how the pressure of the adherence wheels upon the middle rail is obtained. At *i* is a cylinder fixed to the framing of the chassis, in which works a piston. The cylinder is in connection with a compressed air tank which also furnished the supply for the air-brakes of the train. The piston of the cylinder, worked by the compressed air of the tank, is joined by means of rods to a system of levers *l* and *m*, connected across by a rod *n*. The upper end of the second lever *m* is fixed to the cylinder and forms the fixed point of the system. As to the lower ends of the levers, they are connected by means of lugs to the movable frames *e* and as they are connected by the strap *a* they are made to follow the transverse variations of the latter, according to the different positions of the middle rail of the track. From this arrangement it follows that the pressure of the levers acts in the plane of the horizontal adherence wheels, which avoids all tendency to displacement of the vertical shafts *b* and these keep their vertical position and are parallel to each other in all positions of the mechanism, which did not hold good in the former devices. Moreover, the pressure of the adherence wheels is the same on each side of the middle rail. A special device fixed to the car which cannot be described owing to lack of space, gives an automatic distribution of air to the cylinder *i* and this is carried out at a pressure proportional to the grade. When once the device is regulated according to the climatic conditions, the pressure of the horizontal wheels against the central rail is self-regulating according to the slope without needing any attention from the engineer. Thus the second condition mentioned above and which was far from being filled in the Fell locomotive, is now solved in a most satisfactory manner. Without going into the details, the above description shows the new features of the Hanscotte system which is bringing the adherence method into favor owing to its practical advantages.

It was applied for the first time in 1904 at La Bourboule, France, upon the electric tramway which con-

nects the Casino with the incline. The maximum grade was 12 per cent, and a single motor car could be used without the central system, but by adding it the car could be made to take a trailer during the hours of heavy traffic. Fig. 3 shows the motor car which is used at La Bourboule. A second application of the system is upon the road which is to reach the summit of the Puy de Dome, connecting this elevated point with the town of Clermont-Ferrand, and the road, which will be much used by tourists in climbing to this celebrated site, is now about finished. The track will be narrow gauge of one meter (39.37 inches), and the total distance is about nine miles, with a difference of altitude between the two terminal points of

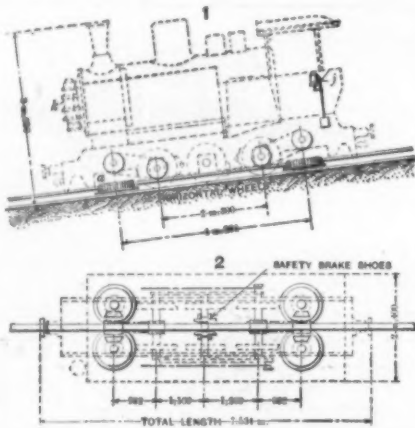


FIG. 5.—DIAGRAM OF A PUY DE DOME LOCOMOTIVE.

3,300 feet. The plan of the road shows many winding curves, some of which have 130 feet radius, and the maximum grades are 12 per cent. Here are used trains drawn by a steam locomotive which is seen in Fig. 4 and in diagram in Fig. 5, being built by the Fives-Lille Company as well as the above-mentioned motor car. It is fitted in the front and rear with the new adherence mechanism and each set is driven by chain from the locomotive axle. When in running order, the weight of the locomotive is 37 tons and the pressure of the four horizontal wheels may vary according to the grades, up to 55 tons. Counting the maximum pressure of 55 tons on the middle rail and an air pressure in the cylinder *i* of 7.67 atmospheres, reckoning the adherence weight of the locomotive at 36 tons and allowing the least coefficient of adherence to be 1-11th, the locomotive with the two adherence devices can easily take a 30-ton train made up of three loaded trailers upon a 12 per cent grade at 7½ miles an hour. Trials have been already made upon the first section of the line which confirm these figures.

An interesting test is being made in France by the Compagnie du Sud de la France upon a line 2½ miles

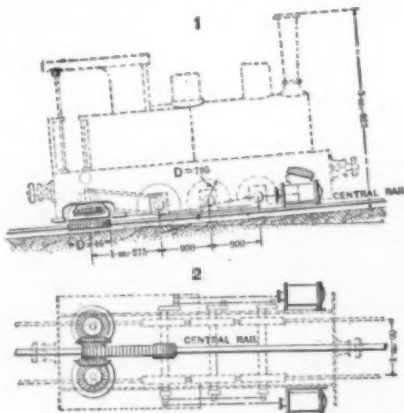


FIG. 6.—DIAGRAM OF THE SUD DE LA FRANCE LOCOMOTIVE.

NEW LOCOMOTIVE SYSTEM.

in length which has many grades, rising to 5 per cent in general. The road connects with the Cape Garonne mines. Here an old 22-ton locomotive with three coupled axles is provided with an adherence mechanism placed back of the fire-box, giving a ten-ton pressure upon the rail (Fig. 6). In this way they could draw upon 5 per cent grades at 5 miles an hour, a weight of 70 tons and over, in place of 33 tons, or an increase of 112 per cent. At railroad crossings the gap in the middle rail is easily covered at the usual speeds.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from La Nature.

Butter powder (said to facilitate the "coming" of the butter).—Bitartrate of potash, colored with some turmeric tincture, is filled into paper capsules, or 10 parts of turmeric powder, and 490 parts of sodium bicarbonate.

ELECTROLYSIS THE CAUSE OF IRON RUST.

ALBERTON S. CUSHMAN read a paper before the American Society of Testing Materials, on "The Corrosion of Iron," which was one of the most noteworthy in the annals of the society. Lantern slide views of the exhaustive experiments conducted by Mr. Cushman were shown and made effective by the actual projection on the screen, of brilliant chemical phenomena supporting the theory that rust is a product of electrolytic action. The paper made an unusual impression, and we present a synopsis of the argument.

The three theories which have been held to account for the rusting and corrosion of iron and steel are the carbonic acid, the hydrogen peroxide and the electrochemical or electrolytic theories. The first two theories which have from time to time been vigorously defended by various investigators, have not been found adequate or borne out by critical investigation. Moody, in England, is the chief modern defender of the carbonic acid theory, but he has committed the error of propounding the theory and then forcing its experiments and observations to agree with it.

Solutions of chromic acid and its salts, such as the chromates and bichromates of potash and soda, have been found to exercise an inhibitive action on the rusting of iron and steel. This inhibitive action is all the more striking from the fact that the chromates are strong oxidizing agents. A solution of potassium bichromate no stronger than one-six-hundredth normal will indefinitely prevent the rusting of polished specimens of metal in cold water, even if free access of air and carbonic acid is provided for. Under the same conditions at a boiling temperature no rusting or pitting takes place if the concentration of the bichromate is above two-one-hundredths normal.

If iron in any of its forms is immersed in strong solutions of bichromate for a few hours the surface becomes passive, even after it is removed from the solution, washed and wiped. The tendency to rust is inhibited as well as the electrolytic exchange with copper, if the metal is dipped for a short time in one per cent copper sulphate solution. This passive condition lasts for some time under ordinary conditions, and steel wire nails that have been chromated may be kept under water for much longer periods than untreated nails, without rusting.

The passive condition gradually disappears and can be removed by heating, scouring, or by placing the metal in a vacuum. The explanation appears to be entirely electro-chemical. No film of oxide is formed but the metal appears to have acquired an oxygen film and is thus polarized in the sense of becoming an oxygen electrode. Iron does not rust in perfectly pure hydrogen peroxide, in which solution oxygen can be made to boil off the surface of polished specimens of iron without producing any speck of rust, even after prolonged periods. Iron rusts in distilled water if oxygen is present, because the iron is attacked by the hydrogen ions supplied by the normal dissociation of water. Iron passes into solution as ferrous hydroxide, which is immediately oxidized to the insoluble red hydroxide and appears as rust.

Acids, acid salts and substances which hydrolyze in solution with an acid reaction stimulate rusting by increasing the concentration of the hydrogen ions. On the other hand, alkalies inhibit rusting in sufficient concentration, by preventing the existence of hydrogen ions.

The rusting of iron is therefore not due to the direct attack of oxygen combined with water. The role of the oxygen is a secondary one and the underlying cause of rusting and corrosion is an electro-chemical or electrolytic problem. Interpreted from this point of view, the rusting of iron invariably proceeds as follows: Iron passes into solution as a ferrous ion by replacing hydrogen which is set free; oxygen then oxidizes the ferrous iron to the ferric condition with the formation of a hydrated oxide. All soluble inhibitors, such as alkaline solutions or chromic acid and its salts, act either by preventing the presence of hydrogen ions or by electro-chemically preventing their attack.

The rusting of iron being essentially an electro-chemical process, is invariably accompanied by electrolytic effects. Differences of potential are established on the surface of the metal, owing to imperfect distribution of metallic impurities, and for other reasons. Positive and negative points, nodes and areas are thus formed, leading to local action and pitting. This electrolytic action can be demonstrated as a universal accompaniment of the rusting of iron. Agaragar and gelatin jellies impregnated with phenol phthalein and potassium ferricyanide invariably show red and blue nodes on specimens of iron and steel imbedded in them. The speaker showed on the screen these alternating red and blue nodes on a wire nail on which rusting was in progress. This combined indicator has been called "ferroxyl." The blue nodes are the positive poles where iron is going into solution; the negative zones are shown in red. No rusting takes place in the red areas except when a change or reversal of the poles

takes place. Pitting is simply a case of persistent positive poles, whereas superficial rusting of a surface is due to frequent changes of potential, with reversals of the positive and negative polar areas. The formation of craters and cones of ferric oxide on the surface of rusting metal was demonstrated by lantern views and explained by the speaker.

As a result of laboratory experiments in demonstration of the electro-chemical theory of rusting, as originally propounded by W. R. Whitney, Mr. Cushman urged that bichromate prevention of iron rust be tried on a practical and useful scale. The paradox is presented by the experiments thus far performed of the prevention of oxidation by one of our strongest oxidizing agents. These experiments show that the active cause of rust is not oxygen but hydrogen; and the action is not oxidation but hydroxidation. What should be aimed at is the inhibition of electrolysis by cutting down the impurities in iron and steel or the unequal distribution of these impurities, as in segregation.—The Iron Age.

THE FORM AND ENERGY OF SEA-WAVES.

A DISCUSSION OF OCEAN MECHANICS.

THE erosion of coasts being produced largely by the dynamic force which is applied by oblique breakers and is transmitted by sea-waves, it is of great importance in studying coast protection to understand clearly what are the ascertained facts concerning sea-waves and what are the generally accepted theories of wave action.

Sea-waves, in the generally accepted sense, owe their origin to wind pressures. The level surface of the sea becomes rippled by the first gusts, and these undulations are increased in size and changed in form by the varying pressures imparted by the wind. The minimum wind velocity capable of generating sea-waves appears to be 2 feet per second, the waves thus produced measuring $\frac{3}{4}$ inch from crest to crest. On the other hand, it is stated that an exceptionally violent gale has been known to produce a sea-wave measuring 2,590 feet from crest to crest. The velocity of the wind and the "fetch," or distance along which propagation is continued, are the principal limiting factors in the form and size of sea-waves; but the duration of the wind force, the depth of the water, and the conformation of the shore, have important bearings on the results produced. On this account it is extremely difficult, if not impossible, to construct a formula giving the height of a sea-wave in the terms of the velocity of the wind, even if a fetch of unlimited distance be assumed.

Wave forms vary considerably during storms, and often one system of waves may be super-imposed upon another, or two systems of waves may travel in different directions. The conjunction of two waves, belonging to separate systems, produces those exceptionally large waves which approach the shore at more or less regular intervals. The original systems of oscillation are lacking in stability and are incapable of being propagated continuously, but these are gradually destroyed after contributing their energy to the more stable forms, and eventually only the trochoidal forms—the truly stable forms—remain.

Sometimes storm waves reach the shore in advance of the storm itself, and, being quite unaccounted for by the direction and velocity of the existing local wind, they act as signals of an approaching storm. This is an interesting phenomenon, because it has been found that the velocity of the wind invariably exceeds that of the waves which it generates. Dr. Gerard Schott found from ten observations that the ratio of the velocity of the wind to that of the sea-waves propagated by it varied between 1.17 and 1.51 to unity, and the results of the observations made by Lieutenant Paris, of the French navy, practically confirm these limits. The ratios calculated from fourteen observations made by Captain Gaillard, of the United States Corps of Engineers, varied between 1.40 and 2.35 to unity. The storm wave which precedes a storm is not, therefore, due to the greater velocity of the wave disturbances.

The velocity of waves in deep water varies as the square root of the wave-length, and practically it is equal to the velocity of a heavy body falling through a distance equal to 8 per cent of the wave length. These deep-water waves are propagated in water whose depth is greater than half a wave-length. They are commonly from about 160 feet to about 320 feet in length, and have a period from about six seconds to about eight seconds. A length of 520 feet and a period of 10 seconds, it is stated, are rarely exceeded. One-half of the total energy of a deep-water wave is kinetic, and is due to the revolution of the water particles. The potential energy, which makes up the other half, is due to the elevation of the center of gravity of the mass of water comprising the crest above the center of gravity of the corresponding mass of still water. The total energy of a deep-water wave 250 feet in length and 15 feet in height is 221 foot-tons per foot of wave-crest, and of one 500 feet in length and 20 feet in height, 793.7 foot-tons per foot. Only one-half of the total energy is transmitted forward with the wave-form, that half being the potential energy.

A wave having a length greater than twice the depth of the water is known as a shallow-water wave. On entering such shallow water, the path of the water particles of a wave becomes elliptical, the eccentricity of the ellipse being governed by the ratio of the wave-length to the depth of the water. As the water becomes more and more shallow the vertical component of the elliptical path tends to disappear, and the move-

ment of the particles to become almost entirely horizontal. The velocity of shallow-water waves is less than that of deep-water waves of equal length, and their energy is slightly less than that of deep-water waves of the same dimensions, the decrease varying with the decreased depth of the water. The shallow-water wave tends to transmit energy in the same manner as a solitary wave of translation when the water shallows gradually and uniformly, and the energy thus transmitted may be nearly the total energy of the wave. If it were not for fluid friction, a solitary wave of translation would deliver its total energy.

The margin of stability of waves is smallest at their crests, and greatest at their troughs; and as the margin of stability at the crest decreases as the ratio of the wave-height to the wave-length increases, the surface tension at the crests of high waves may be so affected as completely to neutralize that margin, and to cause the wave to break. Although the depth of the water may be sufficient for their proper propagation, deep-water waves are liable to break under the disturbing influence of winds and currents. Reefs, shoals, and submerged banks also may cause such waves to break, even in water beyond the hundred-fathom line. In the process of breaking from these causes the wave is retarded in its regular propagation, and is compelled to attain a higher elevation. The crest carried forward by its momentum over-runs the anterior slope, and the wave-form proceeds in a reduced volume, which varies with the reduced depth of water over which it has traveled. Bazin's rule is that a wave breaks when its height exceeds two-thirds of the total depth of water. Irregularity of the sea bottom, sudden shoaling, and the opposition offered by a strong undertow, all hasten the breaking of the waves.

The process of breaking on a shore may be divided into four movements—namely, the movement of the water from the margin of still water toward the face of the crest; the plunge of the breaker, causing a flow of water to the margin of still water; the flow up the slope of the shore; and the flow from whatever height has been attained up the shore to the margin of still water. When a wave breaks, the mass of water which is projected has a velocity usually greater than that of the wave propagation at the time; and, consequently, that the blow which a structure receives from a breaking wave is usually more concentrated and heavier than that which it could have received if the wave had not broken.

Calculations show that the transmitted energy of shallow-water waves decreases rapidly as the depth of the water increases. Stevenson found that the force exerted on the dynamometer by waves estimated to be 6 feet in height was 3,041 pounds per square foot, and that a ground swell 10 feet in height gave the same pressure. Waves 20 feet in height gave a pressure of 4,562 pounds per square foot, and similar waves during a strong gale gave 6,083 pounds. He also found that waves exert by far the greatest force at the level of high water, that the force of recoil is greater than the direct impact, and, with regard to a wall with a steep curved profile, that the vertical force was about 84 times greater than the horizontal. A true wave of oscillation, on reaching a wall having an inclination with the horizontal of from 45 deg. to 90 deg., will not be broken, and will exert practically no dynamic pressure against it. On the other hand, a wall of this profile receives the greatest shock from transitory waves.

By means of dynamometers Lieut.-Col. H. M. Roberts, of the United States Corps of Engineers, obtained readings indicating that waves rising from 14 feet to 18 feet above still-water level, and having a velocity of from 30 miles to 40 miles per hour, exerted a pressure at still-water level of 400 pounds to 600 pounds per square foot; at 16 feet and at 8 feet below still-water level, less than 10 pounds per square foot; and at 8 feet above still-water level, 940 pounds per square foot.

The amount of force which is exerted by breaking waves is of importance in the matter of coast erosion. Captain Gaillard, of the United States Corps of Engineers, used specially constructed dynamometers for taking observations of this force in its direct application, and he found that breakers 2 feet in height and 46 feet in length gave a maximum pressure of 148 pounds per square foot; that those 3 feet in height and 70 feet in length gave 322 pounds per square foot; that

those 4 feet in height and 82 feet in length gave 406 pounds per square foot; that those 5 feet in height and 120 feet in length gave 467 pounds per square foot; and that those 6 feet in height and 150 feet in length gave 667 pounds per square foot. All these were shore breakers, traveling nearly normal to the shore line, over a hard and regular bottom. There are many instances on record of large blocks of masonry and concrete having been dislodged from breakwaters by the waves, and the computed pressures which must have been exerted on these occasions go to confirm the results obtained by dynamometers.—Gerald Otley Case and Frank J. Gray, in The Contract Journal.

PROGRESS IN WIRELESS TELEGRAPHY.

At the discourse delivered before the Royal Institution of Great Britain, in the latter part of May, Dr. J. A. Fleming discussed recent contributions to electric-wave telegraphy. In this he described the work which has been done of late, both along old lines and in some newer directions, notably in the field of directive radiation. Here the experiments made by Marconi, Braun, and himself were explained, and his ideas of the effects produced. Although this side of the work has not advanced far, some useful results have been secured, particularly those which enable a receiving station to determine, more or less definitely, the direction from which the signals being received are coming.

One phase of this work to which attention was called is the necessity of making a thorough study of the causes which vary the transparency of space to long electric waves. This effect was first noticed by Marconi, and later Fessenden described his own observations. The transparency of the terrestrial atmosphere seems to vary from day to day and from hour to hour. It is better at night than in the daytime. There also seems to be another effect, differing possibly from the other, which is most noticeable near the transmitting antenna. This damping action fluctuates from hour to hour and from month to month, according to laws not yet determined, and too little is known to enable any generalization to be made concerning it.

It would seem that this large field offers great opportunities for the young investigator to exercise his ingenuity and energy to some purpose. The problem of wireless communication cannot be said to have been satisfactorily solved until more is known about the way in which the message is transmitted and about the interfering influences. When the art of telegraphy was invented, the problem of transmission had to be solved. The same situation confronted the telephone, and until the laws governing the transmission of telephonic currents were fairly well understood, the art could not go forward. What is now needed for advancing wireless telegraphy, and what will do more in this direction than the invention of new receiving devices and new methods of setting up electrical waves, is a painstaking and thorough study of the atmospheric conditions which affect the radiation of these waves. The field is, of course, large and difficult to explore, but that is all the more reason why well-directed efforts should be made in it. At first thought it seems as though the work must be done on a working scale out of doors, yet it may not be impossible to devise some laboratory method of studying these actions which will enable the effects of various influences to be simulated and varied at will. It has been found in other arts that the conditions can be studied much better in a laboratory on a small scale. Even though not all of the effects can be introduced, some of them, at least, might be studied, and thus a better position gained for understanding the action of the others.—Electrical Review (N. Y.).

Tree Planting in Pennsylvania.—Pittsburg has a project in hand for planting 2,000,000,000 trees in the basins of the Allegheny and Monongahela rivers and thus checking the disastrous freshets which annually destroy property to the value of millions. If this task is accomplished Pittsburg will be entitled to high credit as a creator and conservator of natural resources invaluable to a large and important section of country stretching from western New York through Pennsylvania and Maryland into West Virginia.—N. Y. Tribune.

ILLUSIONS OF VISION AND THE CANALS OF MARS.

A STUDY OF MARTIAN CANALS BY EXPERIMENTAL METHODS.

BY PROF. ANDREW ELLICOTT DOUGLASS, UNIVERSITY OF ARIZONA.

THAT fascinating mystery, the planet Mars, has again approached the earth this summer. Again the nightly watcher will note the diminishing snow caps at the poles, the dark areas of vegetation, enlarging with the welcome moisture, and, perchance a cloud or two that, lingering over the cold Martian night, is dissipated in the sunrise heat, revealing thus its character.

Again, also, will hundreds of fine dark lines appear, which from their straightness and artificial appearance, seem to attest the existence of highly intelligent beings upon our neighbor.

It is right and natural that we should first regard these faintest of markings as realities upon the planet. The writer can certify to their apparent genuineness, for he has pictured numbers of them in half a dozen favorable oppositions since 1892. To him they were real until time proved that in the faintest markings astronomers failed of satisfactory agreement. In the larger markings, and even in the larger canals, conflicts of evidence do occur, but are never troublesome. One may confidently say that such realities do exist. But with the very faint canals whose numbers reach occasionally well into the hundreds, discordance reigns supreme, and it is frequently found that different drawings by the same artist antagonize each other across the page.

Considerations along these lines led the writer to study seriously the origin of these inconsistent faint canals by the methods of experimental psychology, and the application of these methods has resulted in a new optical illusion and new adaptations of old and well-known phenomena, all of which apply profoundly to the case in hand. Their description and application follow.



Fig. 2.—Photographic Halation Ring About Candle Flame, Formed by Reflection Inside the Glass Plate on which the Picture was Taken Very Similar in its Appearance to the Halo Here Described.

HALO.

The most important of these phenomena is the halo.

To observe this, place Fig. 1 at a distance of six to eight feet from the eye and look at it from time to time, taking care to avoid fatigue. Around it will appear a whitish area limited externally by a faint dark line forming a perfect circle, as if traced by a pair of compasses. This external ring or secondary image has a sensible width and appears blackest on

experiment is by standing a black-headed hat pin in the middle of a white-walled room, and looking at it against the distant white background. Around the head of the pin will then appear this halo, more beau-



Fig. 1.—This Spot Should be Viewed from a Distance of Six or Eight Feet, with Care to Avoid Fatigue or After-images, in Order to See the Fine Dark Halo Ring About It at the Distance Indicated by the Smaller Dot.

tiful than before, suspended in mid-air, in the good old-fashioned manner of saintly halos.

The experiment described above gives the "negative" halo. It will be generally referred to in this article, because it is more easily seen than the "positive." The "positive" form of the halo, however, is most readily seen by a similar method. Let a white-

central spot. It was found that the distance from the edge of the spot to the secondary image is constant; that the width of the secondary image increases to some extent with the size of the spot, and that the intensified area increases its intensification with the size of the spot. If the spot is so small as to be barely visible, the halo may still be seen, but the intensified zone then appears of the same intensity as the background.

If the spot is enlarged sufficiently, both positive and negative halos are seen along its margin, one outside and one inside, so that in a straight line separating light and dark areas, the positive halo may be seen in the dark area, and the negative halo in the light. If two small spots are placed so that their halos intersect, the halo of each may usually be seen complete. If the spots are larger, the halos cannot be traced within each other's precincts, and on enlarging the spots still more, they soon act as one mark with regard to the halo, which assumes an elliptical form around them. From these and other experiments along the same line, it appears that the intensified zone or white area, as I shall generally call it, referring to the negative experiment, displays an increased sensitiveness to presence or absence of color of the spot looked at, but a decided deadening in the perception of details.

My first idea in regard to this halo was that it came to life like the camera ghost, from reflections between lens surfaces in the eye, but I found that it could be produced through any portion of the crystalline lens. A pin hole 1/50 inch in diameter passed before the pupil of the eye demonstrated this.

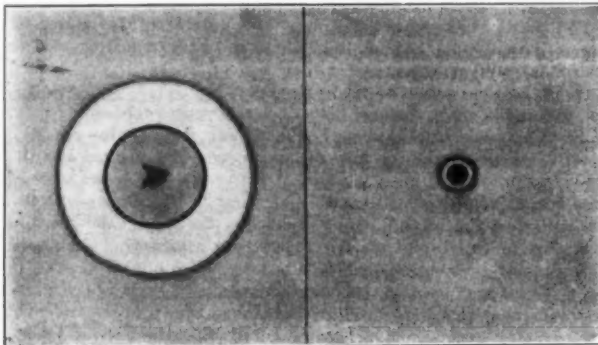


Fig. 5.—"Dot" Mote in Fovea.

Fig. 6.—Same as Fig. 5 Viewed at Close Range Notice Different Length of Rays Compared to Diameter of Ring.

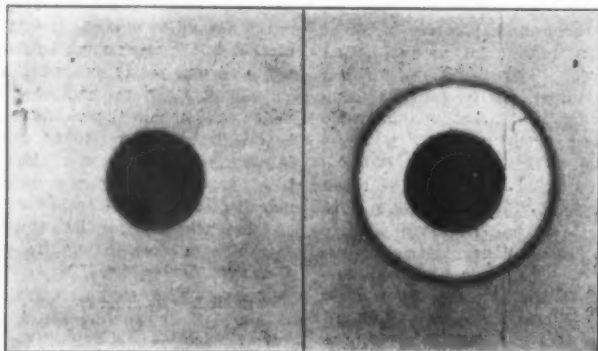


Fig. 3.—"Dot" Mote Outside the Yellow Spot.

Fig. 4.—"Dot" Mote in Yellow Spot but Not in Fovea.

its sharp inner edge. When once caught, which is usually at the first view, it is a striking phenomenon. I find on the whole that trained eyes are the ones which see it most quickly.

A more beautiful and elegant way of making the

an intensified zone in which the color of the background appears stronger; and outside of that a reduction zone, or ring, or secondary image, in which the intensity of the background is reduced by the addition of some of the color of the spot observed.

In order to find the cause of this halo, many tests were made, of which the first was upon the size of the

It then seemed possible that some form of halation in the membranes close to the retina might produce this effect. The common photographic halation ring, which closely resembles it, is produced by reflection from the back of a glass plate but can only occur under certain conditions. This halo, however, occurs on all margins and cannot be due to that cause.

At this stage, a certain "chromatic ring," described below under that heading, was observed, and suggested some obscure color conditions as the cause. Hence, color tests were made in large numbers, and the black spot was tried on different colored backgrounds without effect. Different colored spots against a dark background were also observed without effect, save that the secondary image when sufficiently bright was seen to be of the color of the spot itself; therefore color was not responsible for the halo.

But these color observations opened up a very interesting line of study. The color tests had to be made in the positive form with all the attendant difficulties of fatigue and after-images. It was found that a short gaze at a red disk on a black background, followed by a slight movement of the eye to one side, carried away a dark green after-image of the disk surrounded by a red margin, about the size of the intensified zone. This intensified zone became still more conspicuous by longer fixation of the gaze upon the colored spot. To observe this, half-inch disks of red, yellow, green, and blue paper were pasted vertically on ends of long needles and placed in strong lamp-light at a distance of eight feet from the eye. After long unwinking gaze at one of these disks, until general color sensitiveness seemed to be disappearing and the color of the disk itself seemed to be spreading out around it, a quick closing of the eye, or the mere placing of a sheet of paper close before the open eyes,

revealed a very interesting succession of changes, as follows:

1. A black or dark green disk with a limited red margin filling the intensified zone, limited by the dark halo. This effect lasted for a very brief instant of time, like the common positive after-image.

2. The outline soon reappeared; the red disk and all white objects taking a dark indigo-blue color, the remainder of the field being a bright yellow. This effect might last a minute or two.

3. During the height of this effect a negative halo appeared for a time around the dark after-image of the disk at the usual distance of 7 min. The success of this experiment depends largely upon steadiness of vision and avoidance of winking. The determination of the effect of different colors and conditions offers a fine field for investigation.

The next test with a view to locating the cause of this halo phenomenon was made on notes that so often float by the line of vision. This was done by looking at a highly-illuminated area through a small pin hole held close to the eye. Three classes of notes were observed: First, the usual cell fragments and groups; second, rapidly moving objects probably of similar character, and, third, minute black dots which from their motions seemed to be located in the same region as the first, probably not far in front of the retina. On this last class, some beautiful halo phenomena were observed.

When one of these spots was outside a region identified as approximately the yellow spot, it appeared as a circular dark area of some 30 min. diameter, as shown in Fig. 3. When it came within the yellow spot, it became lighter, and was surrounded by the halo, with its intensified zone and secondary image well defined, as in Fig. 4. When, however, it came within the region of most distinct vision, which was very rare, it gave the most beautiful halo effect I have yet seen. It had a dense, black spot in its very center, usually well rayed; then a light zone limited by an intense black ring, which in turn produced its own complete halo. This form is shown in Fig. 5.

This note observation is by no means easy. I have often waited fifteen minutes for a mote of this type to appear, and only once have I kept one in sight for any length of time. It then remained in the center of vision for at least twenty minutes. Usually, they float past the center of the vision and give one only a brief view. The size of the pin hole used is $1/50$ inch. With a much larger hole, say $1/20$ inch, they become blurred. By getting near a large lamp shade so that a wide angle of light is viewed, they are best discovered. Then one may retreat from the light and view them as illustrated in Figs. 3, 4, and 5.

The rays observed in the central spot are very interesting. Their length offers a means of measuring the height of the spot above the retina. A short calculation upon approximate data results in 0.002 inch as the distance of the spot from the retina.

It is true that these mote observations require great patience, but the beauty of the phenomena repays the effort. There is a sharpness and a density about the inner halo around the spot itself which does not characterize the ordinary outer halo. For such differences I have no explanation to offer.

Not only is the cause of these details very difficult of detection, but the origin of the whole halo phenomenon is equally so. It probably lies in the obscure reactions that change light waves into nerve impulses. One thing which the intensified zone does do is to help correct for rays which the irregular refraction of the eye scatters across a margin; and so this light area fulfills some psychological necessity.

The fact that in the first flash of after-images this zone becomes occupied by the color of the object look-

The significance and application of the phenomena are easier. From the psychological standpoint, its immediate application is to questions of contrast. Contrasts are divided into two classes: First, successive contrast, due to fatigue and rest; second, simultaneous or marginal contrast, now seen to be a subordinate part of this halo phenomenon. Marginal

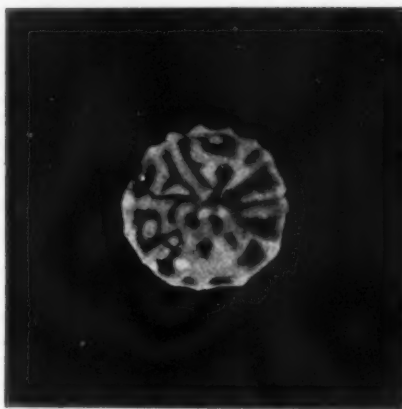


Fig. 8.—Structure Lines in Crystalline Lens.

contrast has been long known, and its after-image, the "Lichthof" of Hering, has been described. The fact that the halo phenomenon definitely limits the region of marginal contrast and displays a secondary image in a definite position proves it to be the more fundamental phenomenon. We have here, therefore, a new illusion of interest to psychologists and of great significance in its application to astronomical work.

RAYS.

Unlike the halo, the ray phenomena are familiar and involve no new principle, but the idea of rays around a black spot is new to me, and quite as important as the halo in its application to visual work by telescope or microscope. As all know, the rays on a star are produced by irregular refraction in the eye, originating in what are known as the stellate figures. The figures seem to be construction lines, as it were,



Fig. 9.—Rays on a Black Spot Obtained by Screening all the Pupil Except the Margin of the (Left) Side.

These Rays are the Two Long Rays on the Left in Fig. 7.

in the crystalline lens, and develop during its growth. They are permanent in form, when adult years are reached, and may be seen with ease by the methods commonly explained in books upon experimental psychology.

If white rays may be seen around a white star on a dark background, then black rays must be visible around a black spot on a white background. They may be easily seen by screening the greater part of the pupil and allowing light from a black spot to pass through its margin. This is best done by a small circular screen on the point of a needle. By slight perseverance all the principal rays seen on a star may be perceived on the black spot. These are always present in the eye, but are not commonly perceived, because they are drowned out in the lighter background, and habit compels us to disregard them. Their importance in astronomical work is at once evident when I state that with the head in a definite position, I found it easier to see certain lines on the planet Mars and those easier lines coincided in direction with the two black rays represented in Fig. 9. It is evident that observations made with the greatest possible care ought to show these canals like marks, and if two of these rays be parallel, as may easily happen in an astigmatic eye, some of the canals should appear double.

Irradiation.—Next to the black rays in importance is the matter of irradiation as analyzed by means of ray forms. The method of investigation is as follows: Make a small hole in a window blind and observe the sky through it by different distances. From near-by the outline of the hole is well perceived, but, as one draws away, the rays soon obscure the hole itself, so that its form and size can not be perceived. At these different distances, the width of the rays varies with the true angular size of the hole. For example, I found at ten feet an irradiation of 2 min., and at three feet an irradiation of 6 min., because at the nearer point the rays are three times as wide and overlap each other at three times the distance from the hole. Irradiation then is the merging together of the rays, and on any straight line of separation, is proportional to the total ray light on the corresponding hemisphere about a star.

Color, size, intensity, and perfection of the eye are

positive factors in irradiation. The negative factor is the background, and the result depends upon the sensitiveness of the eye at the time of observation. Some general results we can see at once. Irradiation is not necessarily the same in any two eyes or in any two directions. It varies with fatigue of the retina and probably with use of the eye in some unusual position, producing unusual conditions of pressure upon the eye-ball. Ordinarily, its amount depends directly on contrast between the areas observed and on the size of the central nucleus of rays in the desired direction. This nucleus must not be assumed to be centrally located on its source.

Best Part of Lens.—A very important bit of information derived in this study of the rays is the location and size of the best part of the crystalline lens. This is done by trying smaller and smaller diaphragms over the eye until the rays cease to appear. They will be found to persist in rudimentary form even when the diaphragm is as small as $1/16$ of an inch. This is of great significance in telescopic and microscopic work, because it shows how small the emergent pencil of light must be to avoid the excessive formation of rays. Even at best, they can not be hindered entirely. The use of lower powers with large emergent pencil is therefore very dangerous. The optically superior part of the lens occupies a small irregular area near the center with irregular extensions out toward the margin. Even the best part is far from perfect.

Detached Spots.—An interesting variation of stellar rays has been observed at least in one case. A gentleman drew for me the rays as they appeared to his eye in the experiment described above (see Fig. 7), and while working asked me if I had placed a number of smaller pin holes around the large one. Fig. 10 represents this. It is perfectly possible for detached spots of this kind to be produced by some irregularity of the lens structure and thus to supply illusive satellites to planets or fictitious companions to double stars.

CHROMATIC RINGS.

The illusive chromatic rings which follow do not bear so much on questions of Martian topography as the preceding halo and rays. Yet they are interesting of themselves and have an influence on color estimations. The first is the broad prismatic ring which extends from about $3\frac{1}{2}$ deg. to 5 deg. from the source of light with red on the outside and green or blue on the inside. This shows well on any brilliant light such as the full moon or a bright electric light.

The second is a narrow blue ring, of interest on account of its beauty. It is best seen on an electric arc light of intense blue color—and the less continuous spectrum the light shows, the better. Standing at a distance of one hundred and fifty or two hundred feet, one may see a beautiful narrow blue line forming a circle fully two feet in diameter about the light. As the color of the light changes to yellow, which it frequently does, the ring rapidly disappears into the center of the light.

This ring may be seen in the laboratory by passing the blue light of the spectrum through a pin hole. In mid-blue its radius is about 12 min. Various experiments show that this illusion is produced at the margin of the pupil by the bending of the blue rays too sharply toward the optical axis of the eye. These rays therefore focus in front of the retina and on reaching it form a blue ring outside of the true image.

RADIATING LINES FROM NEAR THE CENTER OF A BLANK DISK.

The only remaining illusion to which I call atten-

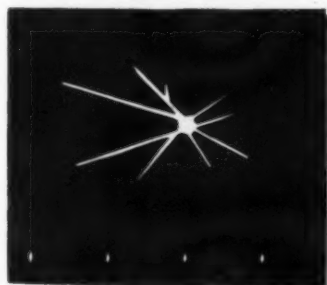


Fig. 7.—Stellar Rays.

ed at (like the common positive after-image) suggests that it is a zone in a condition of expectant attention with reference to that color. If, for example, a red disk is observed, the nerves that perceive that color are in full activity, where the stimulus of the image falls on the retina. For a certain distance away from the active retina, they are aroused into a condition of readiness for activity or expectant attention. The secondary image acts like the fatigue area, for it reverses in the after-image.



Fig. 10.—Rays and Detached Spots.

tion is one of much importance in planetary work, but one for which I shall not attempt an explanation. Frequently in observing a blank white disk, lines have appeared to me to radiate from some point near the center. When first I observed lines of that character, not knowing whether they were really there or not, I considered them genuine and for a long time represented them in the form of a star with four or eight rays. At last when they did not show agreement among themselves I concluded they must be il-

lusions. This was verified by special trial, proving that such lines appear on perfectly blank areas. The rays so observed are sometimes double.

APPLICATION OF THESE PHENOMENA.

Against the obstacles of bad atmosphere, minuteness of detail and faintness, the observer has to wage a hard fight, and it is a matter of congratulation that he sees such faint canal-like marks on the very limit of vision. With full rays the public may then discuss the interpretation.

The ray illusion is to me a very satisfactory explanation of many faint canals radiating from those small spots on Mars, called "lakes" or "oases." The only objective reality in such cases is the spot from which they start. The reader will notice that rays on opposite sides of a star are usually in line. So when two lakes or oases lie along such a line they will appear connected by a canal. Nor do the oases need to be very close together. A ray 16 min. long to the naked eye appears 4 min. long on a planet magnified 240 diameters. With the planet Mars 16 sec. in diameter the ray then extends one-fourth across it. It appears like a canal over one thousand miles long.

I believe the industrious observer has found and will find it difficult to avoid instinctively placing his head in a position favorable to producing combinations of this kind. After he has laboriously memorized the leading details, so that he may recognize what he sees, when, for an instant, Heaven vouchsafes him a brief view, he naturally has a powerful inclination always to observe in the same posture, for he finds that with a slight movement of his head

his structure of fainter canals is liable to disorganization. This insistence upon the same attitude is at once understood when we consider a larger part of the faint canals to be due to rays in the eye.

We have here the medicine to prevent this disease in the future. Let the observer constantly vary the position of the head. As soon as the seeing becomes sufficiently good to reveal fine detail, let the movement of the head begin. A rotation through an arc of twenty or thirty degrees ought to be large enough to test thoroughly any fancied combination of canals. Drawings carefully made in this way will have one source of error eliminated.

The halo with its light area and secondary image accounts for details which have no objective reality, such as bright limbs of definite width, canals paralleling the limb or dark areas, numerous light margins along dark areas and light areas in the midst of dark—abundantly exemplified in Schiaparelli's map of 1881-2.

When a ribbon-like mark has sufficient width, it must appear double; for the positive secondary image of the adjacent light areas will appear within it. To this end its apparent width to the naked eye must be some 8 min. or 10 min. (if eyes are alike in this dimension). In a telescope magnifying any, 400 diameters, this width need be only a little over 1 sec. If the planet is 16 sec. in diameter (a rough average of its favorable position in recent years) this will amount to closely 10 deg. on its surface. Now the double canals of Schiaparelli, in 1881-2, and of Perrotin and Thallon, in 1886, are frankly of this width and, I believe, are due to this cause. In any case

the test to be applied is evidently the relation between the apparent width of a double and the radius of the halo illusion. The prevention of error in the future will evidently be the application of different powers to each canal, particularly a low power which will make its width appear less than 6 min. This must be done with care, for low powers increase the number of rays.

The halo illusion is also responsible for marginal canals. When a dark area becomes 6 min. or 8 min. wide, it appears double, having a light interior and dark edges. With any increase of width the dark edges, giving the effect of the marginal canals, remain. Hence along the edge of any dark area there appears a fictitious canal. Prof. E. W. Maunder observed this in his excellent artificial planet study of a few years ago. I believe that high powers by reducing contrast will help to eliminate this error.

The mention of the chromatic rings draws attention to chromatic aberration in the eye and in the telescope. This effect in the telescope is so great that colors in a refracting telescope are not in the least trustworthy. The blue-green tint attributed to the dark areas on Mars is a product of the telescope. Its existence on our neighbor can only be verified by the use of a reflector.

Thus in conclusion we see that there are fundamental defects in the human eye producing faint canal illusions, that these have worked serious injury to our observations in the past and that in the future they may be avoided chiefly by the simple expedients of varying the position of the head and using a wide range of magnifying power.

GLACIAL GEOLOGY.*

MODERN THEORIES OF GLACIAL CLIMATE.

BY WILLIAM NORTH RICE.

SURELY no part of the world affords better opportunity for the study of glacial geology than America. Its ice sheet, four million square miles in area, far exceeds any of the ice sheets of the Old World. The imbricated sheets of till in the Mississippi Valley afford clear evidence of the complex series of glacial and interglacial epochs. The driftless islands in the vast area of till, and the interlobate moraines, show the division of the marginal portion of the ice sheet into lobes determined by the topography. The old beaches along the shores of the Great Lakes, the living Niagara, and the various extinct Niagaras, record the stages of the melting of the ice. The Malaspina Glacier affords illustrations of the formation of eskers and of other phenomena which must have marked the stagnant margin of the waning ice sheet. Surely our country affords most favorable conditions for the study of the history of the Glacial period.

It is a curious fact that the first published suggestion of the agency of ice in connection with the drift came from a cotton manufacturer in Connecticut, Peter Dobson by name. In the *American Journal of Science*, in 1826, he gives a very clear and satisfactory description of the glaciated boulders observed in the drift, and gives as his conclusion: "I think we can not account for their appearances unless we call in the aid of ice along with water, and that they (the boulders) have been worn by being suspended and carried in ice, over rocks and earth, under water." It was his idea that these boulders were lifted from the bottom of the sea by sheets of anchor ice. This theory was certainly more satisfactory than most of the theories in vogue before that time, and more satisfactory than many of the opinions held at a later date.

The credit of the introduction and championship of the glacier theory of the drift belongs, not to a native, but to an adopted citizen of this country. Louis Agassiz came to this country in 1846. In his early home in Switzerland, he had already adopted the belief of Venetz and Charpentier in the former great extension of the Alpine glaciers, and their agency in the transportation of blocks from the Alps across the Swiss lowland to the Jura. It is, indeed, a curious fact that these Swiss geologists were anticipated, in the conception of the transportation of these blocks through the agency of glaciers, by Playfair, who suggested the idea in 1802. In the early papers of Agassiz the conception of the Glacial period took a form which he himself later recognized as an exaggeration. He conceived at first of a fall of temperature so widespread and so extreme that a polar ice cap extended southward over the whole breadth of Europe and across the Mediterranean, reaching the Atlas Mountains. Later he recognized the ice sheet that covered the Alps as entirely separate from the ice sheet of northern Europe. The tendency to an exaggerated view of the Glacial period overcame him again in later years, when

he maintained that, at the climax of the Glacial period, there was "floating ice under the equator, such as now exists on the coasts of Greenland." Incidentally, he based upon this extravagant conception of the Glacial period an argument against Darwin's views of the origin of species, maintaining that the widespread cold of the Glacial period produced a general extermination of life, necessitating a new creation. But the extravagance of some of his conceptions, and his vain attempt to stop the resistless progress of the doctrine of evolution, may well be forgiven, in memory of the great service which he rendered in bringing into general acceptance the glacier theory of the drift.

As Agassiz traveled in various parts of his adopted country, he recognized everywhere in the northern states the traces of glaciation, already familiar to him in Switzerland and in Scotland; and his views found more ready acceptance in this country than in some of the countries of Europe. Guyot, who had been associated with Agassiz in the study of the glaciers of Switzerland, came to this country in 1848; and he was, of course, a strong ally in the defense of the glacier theory. As early as 1841 Edward Hitchcock had been so strongly impressed by the writings of Agassiz that he recognized clearly the traces of glaciers in Massachusetts; and, in his presidential address before the Association of American Geologists, and in the postscript to his "Final Report on the Geology of Massachusetts," he shows himself almost persuaded to adopt the glacier theory for the explanation of the drift in general. He could not, however, quite bring himself to the acceptance of the conception of a glacier capable of moving with so little slope as to be able to transport material southward over the whole of northeastern America; and he accordingly limited the action of glaciers to those cases in which the drift appeared to be dispersed somewhat radially from local centers in mountainous or hilly regions. The general southward movement of the drift seemed to him to require the conception of submergence of the land, and transportation by icebergs floating southward from the Arctic regions. As early as 1852, one of the best and most popular text-books of the time, that of Gray and Adams, gave the preference to the glacier theory of the drift. Dana, in his presidential address before the American Association for the Advancement of Science, in 1855, manifestly inclined to the glacier theory; and, in the first edition of his "Manual of Geology," in 1862, he gave his adhesion more decidedly to that view. The next generation of American students of geology were brought up on the various editions of Dana's "Manual" and "Text-Book," so that thenceforward the glacier theory was recognized in this country as orthodox. In some of the countries of Europe the theory of submergence and transportation of boulders by icebergs held the ground longer. In 1864 Lyell still maintained the submergence of the plain of northern Europe, and of the glaciated region of North America; and it was not until 1875 that Torell, in a memorable meeting of

the German Geological Society, convinced the German geologists that the drift of northern Germany was transported by an ice sheet whose center was in the mountains of Scandinavia, and the name *Diluvium*, though still used in German geological writings, was completely emptied of its original connotation.

Within the last few decades the labors of a large number of earnest and able investigators have developed the glacier theory more in detail, and have added vastly to our knowledge of Quaternary history. The imaginary polar ice cap has given place to ice sheets of more limited dimensions, though still vast, developed respectively about the Laurentide, Keewatin and Cordilleran centers. The series of terminal moraines, marking stages of readvance or halts in the retreat of the ice sheet, have been carefully mapped. From the experience gained in the study of terminal moraines in this country, Lewis was enabled, in 1886, to recognize and interpret the terminal moraines of the ice sheet in England; and Salisbury, in the following year, those of north Germany. The recognition of interlobate moraines and of driftless areas led to a clearer understanding of the nature of the movement of the great ice sheet. The driftless area of Wisconsin was noticed by J. D. Whitney as early as 1862, and has been more carefully studied by Chamberlin and Salisbury; and the latter investigator has called attention to a smaller driftless area in Illinois. The Quaternary period, instead of being brief and comparatively simple, has been shown to be of long duration and great complexity. It has been analyzed into a succession of glacial and interglacial epochs; and, from the vast amount of erosion in some of the interglacial epochs, it has been inferred that post-Glacial time is very short in comparison with inter-Glacial time. The history of the series of lakes held between the front of the receding ice sheet and the southern watershed of the Saint Lawrence basin, has been studied by Gilbert, Taylor, Fairchild, and others. In Chamberlin's theory that the cause of the Glacial climate is primarily the diminution of the amount of carbon dioxide in the atmosphere, and that the location of the main centers of glaciation is due to the path of cyclonic storms, we have a theory which, if it can not be accepted with full confidence as the true one, is at least the only theory of the Glacial climate which has not yet been weighed in the balance and found wanting. There seems still to be some disagreement among physicists on the critical question, what effect small changes in the amount of carbon dioxide in the atmosphere would produce upon the climate. The views of Arrhenius, upon which the theory of Chamberlin is based, have been contested by Angström and Very, and are not accepted by Hann. If the physicists can be brought to an agreement on this fundamental point, we may feel that we have, at last, a theory of the Glacial climate. The alternative at present seems to be the acceptance of Chamberlin's theory, or the confession that we have as yet no explanation of the Glacial climate.

*Abstract of a paper read before the American Association for the Advancement of Science.

THE SHAPE OF THE EARTH.*

AN EXPLANATION ON THE BASIS OF GRAVITATIONAL STABILITY.

THE most promising suggestion toward a dynamical explanation of the distribution of land and water on the surface of the globe is to be found in the theory of gravitational instability propounded by Jeans in 1903. There is always a tendency in gravitating matter, if homogeneous, to condense toward a center, or toward an axis, or in some more complex fashion. If the matter is heterogeneous, there is always a tendency for the density to increase where it is above the average and to diminish where it is below the average. Such changes of density imply compression of the material, and they are resisted by the elastic force with which the material resists compression. In the case of a planet we may ask two questions: How small must the resistance to compression be in order that sensible condensations may take place? In respect of what changes of density can instability manifest itself? The answers depend greatly upon the size and mass of the planet, and they depend also upon its constitution.

Whatever the internal constitution of a planet may be, it is certain that, owing to the mutual gravitation of its parts, great stresses will be developed within it. A direct method of attacking the problem of gravitational instability for a planet in such a state of stress was proposed by Lord Rayleigh in 1906. The development of this method leads to the result that a homogeneous spherical planet, of the same size and mass as the earth, could not exist unless the resistance to compression of the material of which it is composed were at least half as great as that of steel. If the resistance were less than a quarter of that of steel (so that the substance was less compressible than mercury but more compressible than glass) such a planetary body would be unstable, both as regards concentration of mass toward the center and also as regards displacements by which the density is increased in one hemisphere and diminished in the opposite hemisphere. No matter how small the resistance to compression might be, the body would not be unstable as regards any other type of displacements. If the resistance to compression were small enough for a spherically symmetrical state of aggregation to be unstable, the density of the superficial portions would be less than the mean density, and the center of gravity would not coincide with the center of figure. If the planet were at rest under no external forces, a shallow ocean resting upon it would be drawn permanently toward the side nearer the center of gravity, so that there would be a land hemisphere and a water hemisphere.

The average resistance to compression of the materials of which the earth is composed can be deduced from the observed velocity of propagation of earthquake shocks, and it is found to be decidedly greater than that of any known material at the surface—a result clearly associated with the increase of resistance under great pressure. There is, therefore, no tendency to gravitational instability at the present time; but the actual excess of the mean density over the density of surface rocks, and the fact that a very large proportion of the land lies within a great circle having its center in southeastern Europe, suggest that the resistance to compression was once much smaller than it is now. This suggestion offers a possible dynamical explanation of the fact that the center of gravity does not coincide with the center of figure, and the maintenance of the Pacific Ocean on one side of the globe is due to the eccentric position of the center of gravity.

The actual shape of the lithosphere, or rocky nucleus of the earth, and its situation relative to the geoid, or the equipotential surface which coincides with the surface of the ocean, are due to many causes, of which the eccentric position of the center of gravity is one. Other important causes are the rotation and the attraction of the moon. The moon was once very near the earth, and the day and the month were once nearly equal. The earth was then drawn out toward the moon nearly into the form of an ellipsoid with three unequal axes. The direct result of the rotation and the attraction of the moon would be to give to the lithosphere the shape of an ellipsoid differing slightly from the ellipsoidal figure of the geoid. If the center of gravity coincided with the center of figure, the lithosphere would protrude from the geoid near the North and South Poles, and in two equatorial regions at the opposite ends of the longest equatorial diameter of the lithosphere. If the density were in excess on one side of a diametral plane and in defect on the opposite side, the effects of the rotation, and of those irregularities of attraction which are due to the ellipsoidal figure, would be greater where the density was greater, and the surface of the lithosphere would consequently be deformed in such a way that

the deviation from the ellipsoidal figure could be expressed mathematically by means of a spherical surface harmonic of the third degree. The ellipsoidal deviations from sphericity are expressed by harmonics of the second degree, and the eccentric position of the center of gravity is equivalent to a deviation from symmetry expressed by harmonics of the first degree. We can therefore account theoretically for the presence of harmonics of these three degrees in the formula for the shape of the lithosphere and its situation relative to the geoid.

Now it is known that the actual contour line at mean sphere level (1,400 fathoms below sea level) divides the surface of the globe into two regions of equal area—the continental block and the oceanic region. The continental block is practically continuous, and there are two great ocean basins, one containing the deep parts of the Atlantic and Indian oceans, and the other the deep part of the Pacific Ocean. A spherical harmonic analysis of the distribution of land and water, account being taken of the submerged portions of the continental block, yields the result that the actual outlines of the great ocean basins at mean sphere level coincide very approximately with one of the contour lines of a certain spherical harmonic containing terms of the first, second, and third degrees, but no terms of any higher degree.

It appears, therefore, that the shapes and relative situations of the great ocean basins, and their positions relative to the polar axis, can be described, at least approximately, in the statement that the lithosphere is an ellipsoid with three unequal axes, having its surface deformed according to the formula for a certain spherical harmonic of the third degree, and displaced as a whole relatively to the geoid in the direction toward southeastern Europe. The displacement of the surface as a whole is accounted for by the eccentric position of the center of gravity, and this eccentric position can be regarded as a survival from a past state in which the resistance to compression was too small for a spherically symmetrical configuration to be stable. The ellipsoidal figure is accounted for partly by the rotation and partly as a survival from a past state brought about by the attraction of the moon at the time when the day and the month were nearly equal. The deformation of the ellipsoid according to the formula for a spherical harmonic of the third degree is accounted for as being due to the interaction of the two causes which gave rise to the ellipsoidal figure and to the eccentric position of the center of gravity. The main features of the existing division of the surface into continental and oceanic regions can thus be traced to the operation of simple dynamical laws.—Nature.

THE TEMPLE OF AIZANI.

IN 1833 M. Guizot was Minister of Public Instruction in France and he commissioned Charles Texier, who was then a young architect, to explore Asia Minor and Persia. He lived for several years in those countries and made detailed drawings of the principal buildings. He was the first traveler who gave a precise account of the remarkable ruins at Aizani. Little is known about the history of the place. It is mentioned by Strabo as part of Phrygia Epictetus under the name of Azani. Pausanias says the inhabitants came from Arcadia, and adds: "These Phrygians, who dwell on the borders of the River Peucella, have built there a temple to the Mother of the Gods" and a grotto which is circular and of great height.

The first building that attracts notice on approaching Aizani is a temple, which, being raised on a considerable eminence, forms, like the Parthenon of Athens, a conspicuous object from a distance, and commands the rest of the town. Instead, however, of being, like the Athenian Acropolis, the natural rock, inclosed on its summit with walls, but otherwise quite unshaped, and having its buildings placed quite irregularly without any regard to symmetry of general arrangement, the eminence upon which this temple at Aizani stands forms an elevated platform or terrace cut out of the hill and perfectly regular in its plan, which is a parallelogram and nearly a square, its measurements being 532 feet (English) on its north and south sides and 480 on its east and west. From the remains of walls at the northwest angle, it is conjectured that the platform of the terrace formed a peribolus or court to the temple, inclosed on three of its sides, while the east one (corresponding with the entrance end of the temple) was left open, and on that side the face of the terrace was decorated architecturally throughout its entire extent by a series of twenty-two arches with pilasters between them, i. e., eleven on each side of the central flight of steps (100 feet wide), forming the ascent to the upper level. Thus the terrace here formed a magnificent substructure

ture that, together with the temple, must have produced an unusually striking and imposing effect. The temple itself stands exactly in the center of the peribolus or platform, consequently exactly facing the ascent up to it. This edifice, which appears from inscriptions found among the ruins to have been dedicated to Jupiter of Aizani, is now more than half destroyed, little more remaining than the columns of the north and west sides and the corresponding portions of the cella; yet what is left affords sufficient data for determining with accuracy the particulars in regard to its plan and the peculiar character of its order. The style is Ionic, of the Græco-Roman system, octastyle, pseudodipteral, with fifteen columns on its flanks. Its general dimensions do not exceed 104 feet by 53, or, including the broad socle on which it is raised, 121 by 72. The whole is constructed of white marble, and the columns, 31 feet high, are each of them wrought out of a single block; but what gives such interest to this monument is that it affords a very remarkable example of the Asiatic Ionic, decidedly differing, at least in its entablature, from any specimens heretofore known. The columns have the peculiar Asiatic Ionic base, but are not otherwise remarkable, except for the singularity of there being a small vase or urn carved in the upper part of each channel of the fluting; these are, of course, so very diminutive that they could hardly have been distinguishable at that height, and therefore were probably intended only to produce the effect of an enriched collarino or necking to the capital with the fluting continued through it. Far more remarkable is the entablature, both for its proportions and decorations; the architrave, which is divided into three fascias with carved head moldings, is considerably deeper than the frieze, which excess is caused by the unusual breadth of its coping, consisting of a large ovolo and cavetto above it, both enriched. The frieze is still more remarkable—even 'unique in its design, which is such as to render it most difficult to describe: large upright acanthus leaves placed singly at intervals after the manner of triglyphs are placed beneath a sort of consoles formed by the junction of two scroll-like volutes, meeting each other in front like those at the angle of a Corinthian capital, to which they bear a very strong resemblance; therefore, taken with the acanthus leaves beneath them, they give the frieze a certain Corinthianism of character. The cornice again differs both from Greek and Asiatic-Greek examples of the order, inasmuch as, in addition to the dentils of the latter, it has small modillions; the corona is narrow, the cymatium above it, on the contrary, very deep and enriched with a flower pattern. Taken altogether, this specimen of the Ionic style is an interesting and valuable acquisition to our studies of the ancient orders, and serves as another striking proof of the freedom and diversity with which they were treated.

Beneath the cella is a subterranean chamber or crypt 52 feet by 29 feet 6 inches, with a vaulted ceiling; light was admitted into it by means of *abat-jours*, or apertures in the pavement of the colonnades next the walls of the cella, and the steps leading to it were within the posticum. Several columns now lying on the ground within the peribolus indicate that the inclosure must have been adorned with them, since they evidently do not belong to the temple itself, being not much above half the size of the others, and besides, the lower parts of their flutings are cabled. The temple was probably erected about the second century of our era.

After this temple the chief other monuments discovered at Aizani are a theater, stadium, and gymnasium; the first of these, which is in better preservation than almost any other ancient structure of its kind, is 185 feet in its greatest diameter, and the spectator had sixteen rows of marble seats, but those of the upper or second tier are nearly all destroyed; the podium, however, of that tier, or the wall of the præniction separating it from the lower one, is for the greater part remaining, and shows one peculiarity, namely, niches placed at intervals in pairs, of which there were altogether twenty-four. The orchestra forms more than a semicircle with a radius of 66 feet. The scena was decorated with six pairs of coupled Ionic columns, but these have fallen down and are lying with a mass of other ruins and fragments in the orchestra. The lower range of seats only remain.

The stadium, which is a little to the southeast of the theater, measures 725 feet in its extreme length and 152 feet in its extreme breadth. There were two pulvinaria or loggias, one for the magistrates, the other for the directors of the games, and ten rows of seats along each side, capable of accommodating between 12,000 and 13,000 persons.

Of the gymnasium, or what is supposed to have been such, and which is situated to the south of the peribolus of the great temple, little more remains than a

* Based upon a paper on "The Gravitational Stability of the Earth," by Prof. A. E. H. Love, F.R.S., read before the Royal Society on March 14.

Doric colonnade extending upward of 200 feet, whose pillars are all of white marble and of a single piece. To the northwest of the temple are also some ruins of what is supposed to have been a basilica. The River Rhindacus, which passed through the city, was crossed by two bridges of white marble, each consisting of five semicircular arches. Both are remaining, as also the parapets of the quays along the river, which, like the bridges, are constructed of white marble and ornamented with sculptures.—Architect and Contract Reporter.

SCIENCE NOTES.

A controversy has been long in existence with regard to the origin of the paired fins of fishes, and thus the limbs of vertebrates generally. According to one theory, these fins are derived from gill-structures; the arches, or supports, of the gills having become modified into the shoulder-girdle (scapula and coracoid) and pelvis, while from the gill-flaps, with their supporting gill-rays, the fins themselves have been evolved. According to the alternative view, the fins are modified portions of a longitudinal fold of skin running along each side of the body. It is to be hoped that the controversy may be finally closed as the result of a paper communicated by Mr. Goodrich, of Oxford, to the June issue of the Quarterly Journal of Microscopical Science. Attention is there directed to the fact that the paired fins and the median fins are structurally similar; and that while this is in perfect accord with the lateral-fold theory, it cannot possibly be explained by the gill-theory.

The Homeric poems are supremely important for the insight they afford into the early civilization of the people which they portray, but they contain a great deal that is repulsive to our far more refined sensibilities. Empedocles speaks of but four colors: white, black, red, and pale green. It is hard to believe that the age in which this philosopher lived knew at most only two prismatic colors. It is more probable that he regarded green and blue, and perhaps some other colors, as derivatives from these and therefore not entitled to separate enumeration. According to Democritus, there are but four primitive colors, from which all others are formed by combination. He seems to have regarded blue and green as variants of black. Aristotle thought there were only two primitive colors: light or white and black or dark, and that all others were produced by a mixture of these. Wide as this is from the mark, it shows a tendency to simplify natural phenomena, though it would doubtless be going too far to suspect in this belief an inkling of the composition of light. In the Old Testament four prismatic colors are mentioned, three of them very often and yellow four times, three times in Leviticus and once in the Psalms. In the former it is used of hair; in the latter, of gold. As the Hebrews were surrounded by nations that had made great advances in technical skill, it is probable likewise that all of them had made greater advances in the discrimination of colors than the Greeks.

The term chlorosis has been used to express the gradual disappearance of the green coloring matter or chlorophyll from leaves, young shoots, etc. In some instances this loss of green color extends over the entire surface of the leaf, in others only patches or streaks are destitute of green, giving the leaf a variegated appearance. The cause of this variegation is unknown; it is hereditary in many varieties of plants. Dr. E. Baur has recently described, in Ber. d. deutsch. Bot. Gesellschaft, a form of variegation, which he calls infectious chlorosis, differing from ordinary chlorosis in its power of imparting, through a supposed virus, its peculiarity to another allied plant. This peculiar form of chlorosis exists in certain members of the mallow family, in privet, laburnum, and is in all probability of widespread occurrence. The cultivated variegated mallows were derived from a form of *Abutilon striatum*, called *A. Thomsoni*. This plant transmits its variegated condition by grafting. Baur observed that if the leaves are removed, and the plant is kept in the dark, the new shoots produce only very few variegated leaves, and if those are removed the plant remains permanently green in the light, unless it is again infected by grafting scions of a variegated plant. If latent axillary buds of the old portions of a plant treated as above produce variegated leaves, the whole plant quickly becomes infected. When scions of the immune *A. arboreum* are grafted on the infected *A. Thomsoni*, they grow readily, but do not become infected, whereas if scions of a susceptible kind are in turn grafted on the piece of *A. arboreum* of the previous experiment, they become infected, thus proving that the virus can travel unchanged through the intermediate piece of *A. arboreum*; shoots bearing green leaves that are immune to the disease sometimes appear on *A. Thomsoni*. If one of these shoots is grafted on a variegated plant, the scion continues to produce green leaves. If, in turn, a susceptible scion is grafted on to the immune branch, its leaves are variegated, proving that the virus passed through the

immune branch. This passing of the virus unaffected through a portion of an immune branch does not always hold good. If a scion of *Lavatera arborea* is grafted on *A. Thomsoni*, and another susceptible portion is in turn grafted on the *L. arborea* portion, the leaves do not become variegated, showing that the virus loses its potency in passing into the immune scion of *L. arborea*. The author considers that this form of variegation or chlorosis is due to the presence of a virus, depending on light for its production. When grown in the shade, susceptible plants lose the variegation and become green. Experiments proved that the virus travels in the cortex, and not in the wood.

ELECTRICAL NOTES.

According to the recent reports which have appeared in the Swiss journals, there is some talk of a new electric line running to a point near the summit of Mont Blanc. M. Feldmann, who not long since laid out a project for an aerial electric line upon the Wetterhorn, now brings out a plan for a line of somewhat the same character for the slope of Mont Blanc. The first part of the proposed line running between Chamonix, where it connects with the Fayet-St. Gervais-Chamonix electric railroad, and the Bossons glacier, will be laid out on the rack-rail system, but the second part of the line ending at the Aiguille de Midi will be aerial. On this system the cars will be suspended between two stretched cables which take the place of the track. The cables are to be held upon supports at the proper intervals so as to give a continuous roadway for the cars. To the car will be attached a cable which works upon a drum and serves to draw the cars up the incline after the usual manner. At the end station a powerful electric motor will be used to operate the drum. According to the plans, the suspension cables will be 1.8 inch in diameter and the breaking strain is reckoned at 300 tons. Since the car containing twenty passengers represents a weight of only 50 tons, it is observed that even if one of the sustaining cables should be broken, the second cable will have a coefficient of safety equal to 5. As to the position of these cables, there will be one above the car and one below it, the car being provided with two sets of rollers. The estimated cost of the whole plant is about \$800,000.

The question of grounding secondary alternating-current circuits was again brought up at the recent National Electric Light convention in Washington, and the report of the committee which was adopted this year recommended that the grounding of such secondary circuits be made compulsory by the underwriters for all circuits where the potential between any conductor and ground does not exceed 150 volts. Several eminent authorities were quoted as expressing decided views to the effect that such grounding should be absolutely required in the interests of safety to human life. In view of the constantly growing sentiment in favor of such grounding and the unquestionable safeguards which it affords, it is to be hoped that the underwriters will follow this recommendation and soon make such grounding compulsory. It should have been made compulsory long ago, but there is always a certain amount of inertia to be overcome prior to mandatory action, and after all it is not so very many years since such grounding was not authorized at all by the underwriters. As to methods of best securing ground connections, the committee was not prepared to make definite recommendations except that wherever possible ground connection be made to water pipes. It did recommend, however, that more information be gathered as to suitable methods of grounding. The N. E. L. A. convention proceedings of 1906 contained considerable information of value on grounding under different conditions. We have previously noticed a number of methods for this purpose, but it will do no harm to recapitulate them here, since the subject is a very live one and should receive much more earnest attention than it does. One of the surest methods is undoubtedly that of grounding to water pipes at each customer's service as recommended by the committee. This, however, involves considerable expense in some cases, and until grounding is required by the underwriters there may be a few cases where the waterworks officials may object. Another method which has been found cheaper than grounding at each service in some localities is that of running a continuous ground wire from a station or sub-station over the entire distribution system, this wire being well earthed at points where good grounds can be secured. The method which has heretofore been suggested in the National Electrical Code, namely, that of burying a copper plate in the ground at each transformer, this plate to be surrounded by coke, works well in damp soils, but in New York and Boston and probably in many other cities, has been found to be a very uncertain method because of the uncertainty of permanent moisture. In soils where there is always moist clay to be found a short distance below the surface, as in many portions of the middle West, the ground plate plan works fairly well, but

even there it is a question whether equal reliability is not secured by a cheaper method, namely, that of driving 10 feet of galvanized iron pipe into the ground and making a solid soldered connection with the top of the pipe.—Electrical World.

TRADE NOTES AND FORMULÆ.

Pouring Mixture for Imitation Cameos.—Litharge 50 parts by weight, concentrated glycerine 15 parts, intimately mixed by stirring, is poured into the molds and allowed to stand until it solidifies. By the addition of ochers, ultramarine, chrome yellow, etc., this pouring mixture can be colored as desired.

Composition for Book, Portfolio, and Fancy Box Covers.—Make from starch and water a more or less stiff paste and heat it to 212 deg. to 265 deg. F. until the mass becomes elastic. Then dry at higher or lower temperature. Before heating add to the starch paste, according to wish, the following substances: coloring matter (aniline colors, pigments, bronze shades, other colored powders, animal, vegetable, and mineral fibers), other organic substances (glue, glycerine, gelatine, sugar, honey, rubber, etc.). The mass obtained is pressed in plates and ground down.

Substitutes for Bristles and Whalebone.—Fibers of suitable plants (plassava, alpha grass, etc.) are combined by an adhesive. For the latter are used: Solution of silicate of soda, alone or mixed with heavy spar or chalk, or all sorts of gums, glue, shellac, etc. The coherent mass is cut into strips, and after drying is provided with a coating of celluloid, glue, etc. To render the mass waterproof, it is also given a coating of rubber solution, copal, or similar resins. Finally, the composition receives a covering of metal foil, silk, cotton, linen, etc.

Cameo Picture Mass (Watt's Process).—Marble cement is mixed with a mixture of egg yolk and water and the thin mass, which can be variously colored, is brought into the desired shape by means of a brush. The molds are silvered inside and are oiled before use. The figures in the mold are first filled with the mass, and after this has hardened, the entire form is filled out with a mass of a different color. When it is all hardened we have cameos, with the picture side up. They are dried, dusted with soapstone, and brushed off with a soft brush; they can also be saturated with stearine.

Imitation of Porcelain Cameos.—First prepare the frit, 25,000 parts of white quartzose sand, 16,000 parts of white potash, and 8,000 parts of soda, pulverized, sifted, and well mixed in a basin lined with well-rammed sand, attached to the hearth of a faience kiln. The frit is brought out of the kiln, cleaned, broken, and ground in a faience mill with sandstones. To 2 parts of ground frit take 1 part of porcelain mass (previously washed in the ordinary manner). Blue color for cameos: 50 parts of cameo mixture, 2½ parts of washed porcelain clay, and 5½ parts of cobalt blue (the latter composed of ½ part of cobalt previously ground and sifted in the furnace buried to the half in sand, exposed to a hot faience fire, crushed, sifted, to 2 parts, 1 part of frit added, returned to the furnace). Preparation of cameos: Ring-shaped copper mold evenly filled with white cameo mass, above and beneath white paper and felt disks arranged. The whole placed under a press. Taken out and felt disks removed, cobalt blue applied, disks replaced and returned to the press. Taken out and kept between moist cloths in a damp place. Application of the cameo: Copper plate on which the desired object is engraved in the form of a seal, rubbed off with oil or turpentine spirit, engraved place filled with white cameo substance, placed on the above-described, blue-covered mass, the whole placed under the press. After pressing and removal of the copper plate the cameo is fired in a faience kiln.

Carlsbad Patent Cement.—1. Water glass (1.340 specific gravity). 2. 1 part of washed chalk, 19 parts of kaolin. Mixture alternately replaced by baryta white or precipitated barium sulphate. The object to be warmed; 1 and 2, mixed to a thin paste, edges of fractured parts smeared with it, pressed together, twelve hours to dry.

TABLE OF CONTENTS.

	PAGE
I. ARCHAEOLOGY.—Greek Temples.....	67
The Temple of Aizani.....	79
II. ASTRONOMY.—Illusions of Vision and the Crux of Mars.—8 illustrations.....	78
III. AUTOMOBILES.—Motor Starting Devices for Gasoline Automobiles.—20 illustrations.....	68
IV. CIVIL ENGINEERING.—The De Vries System of Reinforced Concrete Sea Defences.—10 illustrations.....	65
V. ELECTRICITY.—Electrolysis the Cause of Iron Rust.....	74
Progress in Wireless Telegraphy.....	75
Electrical Notes.....	76
VI. GEOLOGY.—Glacial Geology.....	79
The Shape of the Earth.....	79
VII. MECHANICAL ENGINEERING.—New Locomotive System.—6 illustrations.....	73
VIII. MINING AND METALLURGY.—Copper-refining Machinery.—4 illustrations.....	72
IX. MISCELLANEOUS.—The Form and Energy of Sea-waves.....	75
Trade Notes and Formulæ.....	80
Science Notes.....	80
X. TECHNOLOGY.—The Preservation of Timber.....	71

y
t
d
p

e
a
la
t-
is

w
an
fl
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e,
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e,
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spe-
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white
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PAGE	
67	67
68	68
69	69
70	70
71	71
72	72
73	73
74	74
75	75
76	76
77	77
78	78
79	79
80	80
81	81
82	82
83	83
84	84
85	85
86	86
87	87
88	88
89	89
90	90
91	91